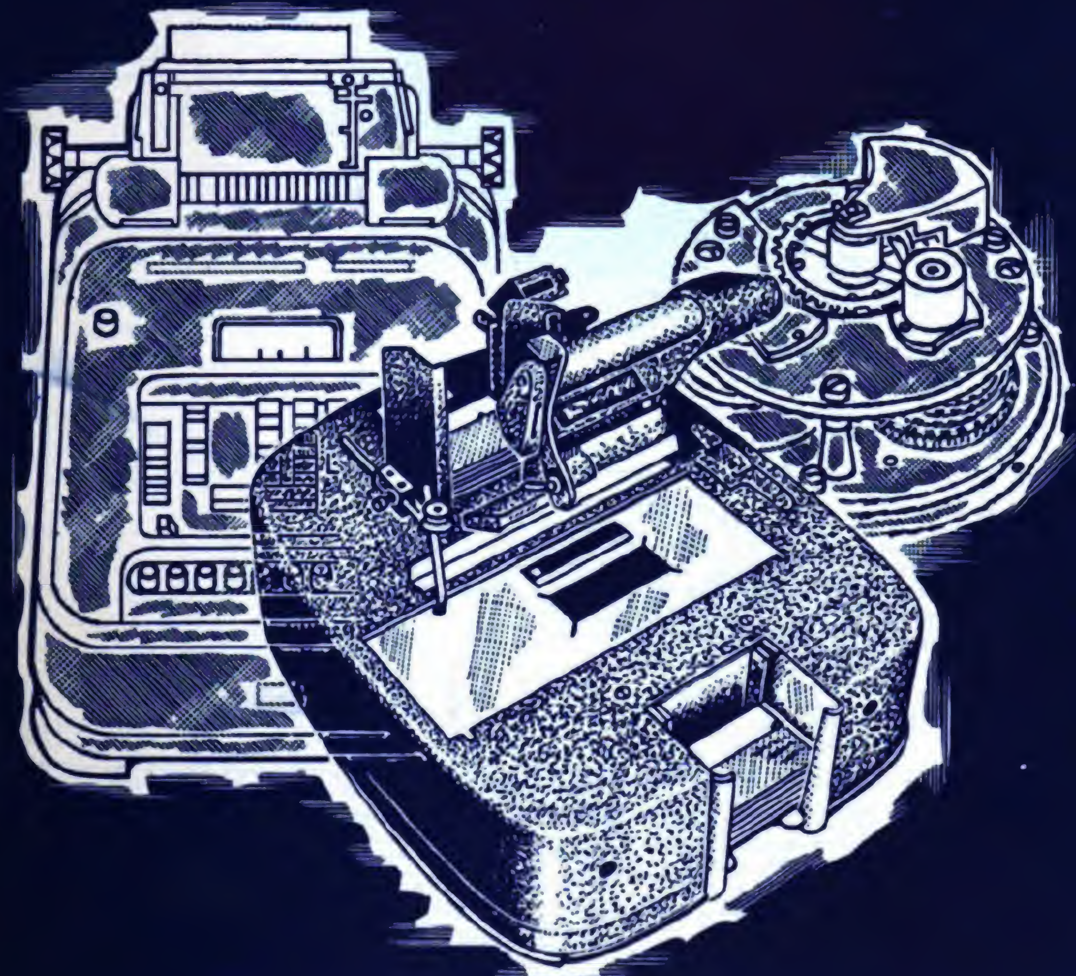

INSTRUMENTMAN 1 & C

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSE NAVPERS 10194-B

PREFACE

This training course was prepared for men of the Navy and of the Naval Reserve who are studying for advancement to the rates of Instrumentman 1 and Chief Instrumentman.

As one of the Navy Training Courses, this book was prepared by the U. S. Navy Training Publications Center, Washington, D.C., for the Bureau of Naval Personnel. Information provided by numerous manufacturers and technical societies is gratefully acknowledged. Technical assistance was provided by the U. S. Navy Instrumentman School, Great Lakes, Illinois; and also by the U. S. Navy Bureau of Ships.

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575

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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READING LIST

NAVY TRAINING COURSES

Basic Handtools, NavPers 10085-A (metal working skills only)

Basic Machines, NavPers 10624 (chapters 1, 3, 4, 6, 9, 10, 11)

Basic Hydraulics, NavPers 16193 (chapters 1, 2, 3, 13)

Blueprint Reading and Sketching, NavPers 10077-B (chapters 1 to 4)

Instrumentman 3 & 2, NavPers 10193-B

OTHER PUBLICATIONS

Adding Machine Manuals:
Burroughs (Series P)
Remington (Models 2 & 3)

Buships Technical Manual (chapters 24, 69, 87)

Calculators:
Friden (Model W's)
Monroe (Model 6N)
Marchant (Model CM)

Cash Register Manuals:
National (Class 21)

Electric Typewriter Manuals:
IBM (Model C-1)
Underwood (Model "Scriptor")

Mechanical Boat and Deck Clocks (Chelsea Type), NavShips 250-624-8

Mechanical Boat and Deck Clocks (Seth Thomas Type), NavShips 250-624-9

Service Manual for Jones Tachometers, NavShips 365-0163

Service Manual for Liquidometers and Levelometers, NavShips 387-0276

Standard Typewriter Manuals:
Remington (Model 19)
Royal (Model MC)
Smith Corona (Series 72E)
Underwood (Models 150 and TM-2)

Watches and Clocks (Maintenance), TM 9-1575

CHAPTER 1

ADVANCEMENT

The purpose of this training course is to help you meet the technical qualifications for advancement to Instrumentman 1 and Chief Instrumentman. Information presented is based on the "A" revision of the Manual of Qualifications for Advancement in Rating, NavPers 18068; changes in the qualifications for Instrumentmen after the "A" revision are therefore not reflected in the discussion.

The second chapter of this training course is devoted to an explanation of the organization and operation of a repair department on a repair ship or a tender, on which you generally will perform duty. As an administrator of an instrument shop, you need an understanding of the administration of divisions in your department; and as a shop supervisor, you definitely need to know how to organize and manage an instrument shop. The last part of chapter 2 is therefore limited to a discussion of the things you must do as a shop superintendent, as a supplement to this phase of your work presented in Instrumentman 3 & 2, NavPers 10193-B.

Chapters 3 through 10 contain detailed information about the mechanisms and parts (and their operation) in manual and electric typewriters; reproducing machines, including Addressographs and graphotypes; adding machines; and watches and clocks. After you study the information presented on these machines in applicable chapters, you will understand how they function; and you will know how to disassemble, repair, clean, reassemble, and adjust them. Experience working on the instruments in shops will enable you gradually to become a proficient Instrumentman.

Chapter 11 explains how to manufacture various instrument parts, which knowledge you will need under certain circumstances during your duty in the Navy.

Chapters 12 and 13 explain the mechanisms and parts of a few instruments; but much emphasis is also given to the procedures for providing corrective maintenance to such instruments as levelometers and liquidometers, flowmeters, various types of gages, dial indicators, and tachometers. Equipment used for testing and calibrating these instruments is also considered in detail, because you cannot perform satisfactory maintenance on the instruments without it.

Chapters 14 and 15 pertain to the functioning of mechanisms and parts in calculators and cash registers, respectively. As was the case with adding machines and electric typewriters, these two machines were not considered in previous training manuals for Instrumentmen.

The qualifications for advancement in rating are not included in the appendices of this training course; but most of them have been listed in condensed form in each chapter, usually at the beginning. They are included in detail, of course, in the Quals Manual (explained later in this chapter).

The remainder of this chapter gives information on the enlisted rating structure, the Instrumentman rating, requirements and procedures for advancing in rating, and references which will help you (1) to work for advancement and (2) to perform your duties with greater proficiency. This chapter also includes information concerning the best use of Navy Training Courses. You should therefore study this chapter CAREFULLY, before you begin intensive study of the other chapters.

THE ENLISTED RATING STRUCTURE

The present enlisted rating structure, established in 1957, includes three types of ratings: general ratings, service ratings, and emergency ratings.

GENERAL RATINGS are designed to provide paths of advancement and career development. A general rating identifies a broad occupational field of related duties and functions requiring

similar aptitudes and qualifications. General ratings provide the primary means used to identify billet requirements and personnel qualifications. Some general ratings include service ratings; others do not. Both Regular Navy and Naval Reserve personnel may hold general ratings.

Subdivisions of certain general ratings are identified as SERVICE RATINGS. These service ratings identify areas of specialization within the scope of a general rating. Service ratings are established in those general ratings in which specialization is essential for efficient utilization of personnel. Although service ratings can exist at any petty officer level, they are most common at the PO3 and PO2 levels. Both Regular Navy and Naval Reserve personnel may hold service ratings.

EMERGENCY RATINGS identify essentially civilian occupations. Emergency ratings are not identified as ratings in the peacetime Navy, but their identification is required in time of war.

THE INSTRUMENTMAN RATING

The Instrumentman rating is a general rating ONLY—there are no service ratings. Because of the nature of the work Instrumentmen perform, the comprehensiveness of its scope and the diversity of abilities required, an Instrumentman should be a man of fairly high intelligence, good emotional stability, and high mechanical aptitude. A background of general and mechanical training is helpful. It takes a well-trained person of calm mind and much patience, for example, to be a good watch repairman. Just ANY ONE cannot do this type of work, no matter how much training he receives. A gage and meter repairman, likewise, must be mechanically-inclined and have a liking for the work in order for him to develop proficiency as a gage and meter mechanic. The same thing is true with respect to the repair of such intricate machines as calculators and cash registers. Some persons would shudder at the mere idea of having to repair such machines; other persons of different temperament and innate mechanical aptitude would cherish the idea of having an opportunity to train for an office machine repairman.

INSTRUMENTMAN BILLETS

An Instrumentman is generally assigned duty in instrument shops aboard repair ships or tenders. On occasions, however, he may be assigned duty ashore as an instructor in an Instrumentman school. Some Instrumentmen receive shore duty in recruiting; others are assigned duty in Naval Reserve training, or in the U. S. Naval Examining Center, Great Lakes, Illinois, where they help to prepare servicewide examinations for advancement in rating. On occasions, Instrumentmen may also be assigned duty in the Navy Training Publications Center, Washington, D.C., to help prepare Navy Training Courses and/or other training materials, such as curricula and correspondence courses.

You should understand by now that the Instrumentman rating is a VERY important rating, without which part of the mission of the Navy would not be accomplished, particularly during emergencies and under certain conditions and circumstances. Remember, then, that you ARE an important person who fills an important position on the TEAM—the United States Navy.

ADMINISTRATIVE RESPONSIBILITIES

When you advance in rating to an Instrumentman 1 or a Chief Instrumentman, your responsibilities for administration increase. Even though you have only one person who reports to you for the work he performs, you ARE an administrator. As the supervisor of the instrument shop, however, you will have four or five Instrumentmen of lower rate assigned to assist you with your work. If your men are content and do high-quality work, it will usually be due to the administrative methods and procedures you use in training them, in organizing and operating your shop, and in supervising their work.

An administrator is a leader. As a shop foreman, you ARE a leader of men. This is the first thing you should learn about the nature of your work as a supervisor. Because you cannot accomplish alone all the work assigned your shop, you must have it performed by others—Instrumentmen. You should then ask yourself: How can I get maximum production from these men? The answer to this question is the crux of your problem—handling individuals of diverse intelligence, abilities, and attitudes.

Do you REALLY want an excellent shop, one worthy of an E? Then start with yourself. Do you know your work WELL ENOUGH, or should you do a little more studying to keep current with the newest ideas and developments with respect to your work? Do you have your shop well organized? Do you have all authorized

equipment and tools, and do you maintain them properly? Are you ON THE JOB most of the time, or do you just DROP BY occasionally? Do you look and act a leader—in appearance, poise, and conversation? Do you treat your men as you would have them treat you, were your positions reversed? Do you listen to them when they have something to say, are you attentive? Are you genuinely interested in their work, their professional development, and even personal affairs?

A good leader knows his men. A good leader knows how to motivate his men as individuals. A good leader has (merits) the respect of his men—he does not have TO EARN IT. An excellent administrator once said: "A good leader is one who can get his workers to do willingly and with pleasure their assigned tasks." Think this statement through, and then use it as a yardstick to evaluate yourself as an administrator (leader). If you cannot honestly rate yourself high as a leader, scrutinize your methods and procedures of operating your shop—processing work requests, handling your men, coordinating and cooperating with other cognizant division and/or tended ships' personnel, supervision of work, and your overall operation. Then take the steps necessary to improve your operation and yourself—personally and professionally. If you do this, your shop will most likely merit an E for excellence.

Department of the Navy General Order 21 pertains to leadership, and a few statements from it are given here for your inspiration and guidance, as follows:

> "The United States Navy-Marine Corps records of victorious achievements on land, at sea, and in the air in peace and war have won for these services an honored position in our great nation. This heritage was passed on to us by our leaders, both officer and enlisted, whose outstanding examples of courage, integrity and devotion to duty are historically significant. They accomplished their missions successfully by high caliber leadership and personal example."
>
> "The objective of this general order is to achieve an ever-improving state of combat readiness by:
>
> a. Emphasizing that successful leadership at all levels is based on personal example and moral responsibility.
>
> b. Insuring that every man and woman are themselves examples of military ideals.
>
> c. Requiring personal attention to and supervision of subordinates."

ADVANCEMENT IN RATING

By this time, you are probably well aware of the personal advantages of advancement in rating—higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also, you have probably discovered that one of the most enduring rewards of advancement is the training you acquire in the process of preparing for advancement.

The Navy also profits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By each advancement in rating, you increase your value to the Navy in two ways. First, you become more valuable as a technical specialist in your own rating. And second, you become more valuable as a person who can supervise, lead, and train others and thus make far-reaching contributions to the entire Navy.

Since you are studying for advancement to PO1 or CPO, you are probably already familiar with the requirements and procedures for advancing in rating. However, you may find it helpful to read the following sections. The Navy does not stand still. Things change all the time, and it is possible that some of the requirements have changed since the last time you were going up for advancement in rating. Furthermore, you will be responsible for training others for advancement, and so will need to know the requirements in some detail.

HOW TO QUALIFY FOR ADVANCEMENT

To qualify for advancement in rating, a person must:

1. Have a certain amount of time in grade.
2. Complete the required military and professional training courses.
3. Demonstrate the ability to perform all the PRACTICAL requirements for advancement by completing applicable portions of the Record of Practical Factors, NavPers 760.
4. Be recommended by his commanding officers.

5. Demonstrate his KNOWLEDGE by passing a written examination on (a) military requirements, and (b) professional qualifications.

Some of these general requirements may be modified in certain ways. Figure 1-1 gives an overall view of the requirements for advancement of active duty personnel; figure 1-2 gives this information for inactive duty personnel.

Remember that the requirements for advancement can change. Check with your division officer or training officer to be sure that you know the most recent requirements.

When you are training lower rated personnel, it is a good idea to point out that advancement in rating is not automatic. Meeting all the requirements makes a person ELIGIBLE for advancement, but it does not guarantee his advancement. Such factors as the score made on the written examination, length of time in service, performance marks, and the quotas for the rating enter into the final determination of who will actually be advanced.

HOW TO PREPARE FOR ADVANCEMENT

Preparations for advancement in rating include studying the qualifications, working on the practical factors, studying the required Navy Training Courses, and studying any other material that may be specified for the rate and rating. To prepare for advancement yourself or to help others prepare for advancement, you will need to be familiar with (1) the Quals Manual, (2) the Record of Practical Factors, NavPers 760, (3) a NavPers publication called Training Publications for Advancement in Rating, NavPers 10052, and (4) Navy Training Courses. The following sections describe these materials and give some information on how to use them to best advantage.

The Quals Manual

The Manual of Qualifications for Advancement in Rating, NavPers 18068A (with changes), gives the minimum requirements for advancement to each rate within each rating. This manual is usually called the "Quals Manual," and the qualifications themselves are often called "quals." The qualifications are of two general types: (1) military requirements, and (2) professional or technical qualifications. Military requirements apply to all ratings rather than to any one rating alone. Professional qualifications are technical or professional requirements that are directly related to the work of each rating.

Both the military requirements and the professional qualifications are divided into subject matter groups. Then, within each subject matter group, they are divided into PRACTICAL FACTORS and KNOWLEDGE FACTORS.

The professional qualifications for advancement in your rating covered in this training course were current at the time this training course was printed. However, the Quals Manual is changed more frequently than Navy Training Courses are revised. By the time you are studying this training course, therefore, the quals for your rating may have been changed. Never trust any set of quals until you have checked it against an UP-TO-DATE copy in the Quals Manual.

In training others for advancement in rating, emphasize these three points about the quals:

1. The quals are the MINIMUM requirements for advancement to each rate within the rating. Personnel who study MORE than the required minimum will have a great advantage when they take the written examinations for advancement.

2. Each qual has a designated rate level—chief, first class, second class, or third class. You are responsible for meeting all quals specified for the rate level to which you are seeking advancement AND all quals specified for lower rate levels.

3. The written examinations for advancement in rating will contain questions relating to the practical factors AND to the knowledge factors of BOTH the military requirements and the professional qualifications.

Record of Practical Factors

A special form known as the RECORD OF PRACTICAL FACTORS, NavPers 760, is used to record the satisfactory performance of the practical factors. This form, which is available for all ratings, lists all the military and all the professional practical factors. Whenever a person demonstrates his ability to perform a practical factor, appropriate entries must be made in the DATE and INITIALS columns. As a PO1 or CPO, you will often be required to check the practical factor performance of lower rated personnel and to report the results to your supervising officer.

As changes are made periodically to the Quals Manual, new forms of NavPers 760 are provided when necessary. Extra space is

ACTIVE DUTY ADVANCEMENT REQUIREMENTS

<table>
<tr><th>REQUIREMENTS *</th><th>E1 to E2</th><th>E2 to E3</th><th>E3 to E4</th><th>E4 to E5</th><th>E5 to E6</th><th>† E6 to E7</th><th>† E7 to E8</th><th>† E8 to E9</th></tr>
<tr><td>SERVICE</td><td>4 mos. service—or completion of recruit training.</td><td>6 mos. as E-2.</td><td>6 mos. as E-3.</td><td>12 mos. as E-4.</td><td>24 mos. as E-5.</td><td>36 mos. as E-6.</td><td rowspan="2">48 mos. as E-7. 8 of 11 years total service must be enlisted. Must be permanent appointment.</td><td rowspan="2">24 mos. as E-8. 10 of 13 years total service must be enlisted.</td></tr>
<tr><td>SCHOOL</td><td>Recruit Training.</td><td></td><td>Class A for PR3, DT3, PT3, AME 3, HM 3</td><td></td><td></td><td>Class B for AGCA, MUCA, MNCA.</td></tr>
<tr><td>PRACTICAL FACTORS</td><td>Locally prepared check-offs.</td><td colspan="7">Records of Practical Factors, NavPers 760, must be completed for E-3 and all PO advancements.</td></tr>
<tr><td>PERFORMANCE TEST</td><td colspan="2"></td><td colspan="4">Specified ratings must complete applicable performance tests before taking examinations.</td><td></td><td></td></tr>
<tr><td>ENLISTED PERFORMANCE EVALUATION</td><td colspan="2">As used by CO when approving advancement.</td><td colspan="6">Counts toward performance factor credit in advancement multiple.</td></tr>
<tr><td>EXAMINATIONS</td><td colspan="2">Locally prepared tests.</td><td colspan="4">Navy-wide examinations required for all PO advancements.</td><td colspan="2">Navy-wide, selection board, and physical.</td></tr>
<tr><td>NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)</td><td></td><td colspan="5">Required for E-3 and all PO advancements unless waived because of school completion, but need not be repeated if identical course has already been completed. See NavPers 10052 (current edition).</td><td colspan="2">Correspondence courses and recommended reading. See NavPers 10052 (current edition).</td></tr>
<tr><td rowspan="2">AUTHORIZATION</td><td colspan="2">Commanding Officer</td><td colspan="3">U.S. Naval Examining Center</td><td colspan="3">Bureau of Naval Personnel</td></tr>
<tr><td colspan="6">TARS attached to the air program are advanced to fill vacancies and must be approved by CNARESTRA.</td><td colspan="2"></td></tr>
</table>

* All advancements require commanding officer's recommendation.
† 2 years obligated service required.

Figure 1-1.—Active duty advancement requirements.

INACTIVE DUTY ADVANCEMENT REQUIREMENTS

REQUIREMENTS *		E1 to E2	E2 to E3	E3 to E4	E4 to E5	E5 to E6	E6 to E7	E8	E9
	FOR THESE DRILLS PER YEAR								
TOTAL TIME IN GRADE	48	6 mos.	6 mos.	15 mos.	18 mos.	24 mos.	36 mos.	48 mos.	24 mos.
	24	9 mos.	9 mos.	15 mos.	18 mos.	24 mos.	36 mos.	48 mos.	24 mos.
	NON-DRILLING	12 mos.	24 mos.	24 mos.	36 mos.	48 mos.	48 mos.		
DRILLS ATTENDED IN GRADE †	48	18	18	45	54	72	108	144	72
	24	16	16	27	32	42	64	85	32
TOTAL TRAINING DUTY IN GRADE †	48	14 days	14 days	14 days	14 days	28 days	42 days	56 days	28 days
	24	14 days	14 days	14 days	14 days	28 days	42 days	56 days	28 days
	NON-DRILLING	None	None	14 days	14 days	28 days	28 days		
PERFORMANCE TESTS				Specified ratings must complete applicable performance tests before taking examination.					
PRACTICAL FACTORS (INCLUDING MILITARY REQUIREMENTS)		Record of Practical Factors, NavPers 760, must be completed for all advancements.							
NAVY TRAINING COURSE (INCLUDING MILITARY REQUIREMENTS)		Completion of applicable course or courses must be entered in service record.							
EXAMINATION		Standard exams are used where available, otherwise locally prepared exams are used.						Standard EXAM, Selection Board, and Physical.	
AUTHORIZATION		District commandant or CNARESTRA					Bureau of Naval Personnel		

* Recommendation by commanding officer required for all advancements.
† Active duty periods may be substituted for drills and training duty.

Figure 1-2.—Inactive duty advancement requirements.

allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but which are not identified as minimum qualifications for advancement. Keep this in mind when you are training and supervising other personnel. If a person demonstrates proficiency in some skill which is not listed in the quals but which is within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made in the Record of Practical Factors.

When you are transferred, the Record of Practical Factors should be forwarded with your service record to your next duty station. It is a good idea to check and be sure that this form is actually inserted in your service record before you are transferred. If the form is not in your record, you may be required to start all over again and requalify in practical factors that have already been checked off. You should also take some responsibility for helping lower rated personnel keep track of their practical factor records when they are transferred.

NavPers 10052

Training Publications for Advancement in Rating, NavPers 10052 (revised) is a very important publication for anyone preparing for advancement in rating. This publication lists required and recommended Navy Training Courses and other reference material to be used by personnel working for advancement in rating. NavPers 10052 is revised and issued once each year by the Bureau of Naval Personnel. Each revised edition is identified by a letter following the NavPers number. When using this publication, be SURE you have the most recent edition.

The required and recommended references are listed by rate level in NavPers 10052. It is important to remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Navy Training Courses that are marked with an asterisk (*) in NavPers 10052 are MANDATORY at the indicated rate levels. A mandatory training course may be completed by (1) passing the appropriate Enlisted Correspondence Course that is based on the mandatory training course; (2) passing locally prepared tests based on the information given in the mandatory training course; or (3) in some cases, successfully completing an appropriate Navy school.

When training personnel for advancement in rating, do not overlook the section of NavPers 10052 which lists the required and recommended references relating to the military requirements for advancement. Personnel of all ratings must complete the mandatory military requirements training course for the appropriate rate level before they can be eligible to advance in rating. Also, make sure that personnel working for advancement study the references which are listed as recommended but not mandatory in NavPers 10052. It is important to remember that ALL references listed in NavPers 10052 may be used as source material for the written examinations, at the appropriate rate levels.

Navy Training Courses

There are two general types of Navy Training Courses. RATING COURSES (such as this one) are prepared for most enlisted ratings. A rating training course gives information that is directly related to the professional qualifications of ONE rating. SUBJECT MATTER COURSES or BASIC COURSES give information that applies to more than one rating.

Navy Training Courses are revised from time to time to bring them up to date. The revision of a Navy Training Course is identified by a letter following the NavPers number. You can tell whether a Navy Training Course is the latest edition by checking the NavPers number (and the letter following the number) in the most recent edition of List of Training Manuals and Correspondence Courses, NavPers 10061.

Navy Training Courses are designed for the special purpose of helping naval personnel prepare for advancement in rating. By this time, you have probably developed your own way of studying these courses. Some of the personnel you train, however, may need guidance in the use of Navy Training Courses. Although there is no single "best" way to study a training course, the following suggestions have proved useful for many people.

1. Study the military requirements and the professional qualifications for your rating before you study the training course, and refer to the quals frequently as you study. Remember, you are studying the training course primarily to meet these quals.

2. Before you begin to study any part of the training course intensively, get acquainted with the entire book. Read the preface and the table of contents. Check through the index. Thumb through the book without any particular plan, looking at the illustrations and reading bits here and there as you see things that interest you.

3. Look at the training course in more detail, to see how it is organized. Look at the table of contents again. Then, chapter by chapter, read the introduction, the headings, and the subheadings. This will give you a pretty clear picture of the scope and content of the book.

4. When you have a general idea of what is in the training course and how it is organized, fill in the details by intensive study. In each study period, try to cover a complete unit—it may be a chapter, a section of a chapter, or a subsection. The amount of material you can cover at one time will vary. If you know the subject well, or if the material is easy, you can cover quite a lot at one time. Difficult or unfamiliar material will require more study time.

5. In studying each unit, write down questions as they occur to you. Many people find it helpful to make a written outline of the unit as they study, or at least to write down the most important ideas.

6. As you study, relate the information in the training course to the knowledge you already have. When you read about a process, a skill, or a situation, ask yourself some questions. Does this information tie in with past experience? Or is this something new and different? How does this information relate to the qualifications for advancement in rating?

7. When you have finished studying a unit, take time out to see what you have learned. Look back over your notes and questions. Without looking at the training course, write down the main ideas you have gotten from studying this unit. Don't just quote the book. If you can't give these ideas in your own words, the chances are that you have not really mastered the information.

8. Use Enlisted Correspondence Courses whenever you can. The correspondence courses are based on Navy Training Courses or other appropriate texts. As mentioned before, completion of a mandatory Navy Training Course can be accomplished by passing an Enlisted Correspondence Course based on the training course. You will probably find it helpful to take other correspondence courses, as well as those based on mandatory training courses. Taking a correspondence course helps you to master the information given in the training course, and also gives you an idea of how much you have learned.

INCREASED RESPONSIBILITIES

When you assumed the duties of a PO3, you began to accept a certain amount of responsibility for the work of others. With each advancement in rating, you accept an increasing responsibility in military matters and in matters relating to the professional work of your rating. When you advance to PO1 or CPO, you will find a noticeable increase in your responsibilities for leadership, supervision, training, working with others, and keeping up with new developments.

As your responsibilities increase, your ability to communicate clearly and effectively must also increase. The simplest and most direct means of communication is a common language. The basic requirement for effective communication is therefore a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

Leadership and Supervision

As a PO1 or CPO, you will be regarded as a leader and supervisor. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical, on-the-job language that can be understood and followed by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their jobs correctly. At the same time, you must be able to explain to officers any important problems or needs of enlisted personnel. In all military and professional matters, your responsibilities will extend both upward and downward.

Along with your increased responsibilities, you will also have increased authority. Officers and petty officers have POSITIONAL authority—that is, their authority over others lies in their positions. If your CO is relieved, for example, he no longer has the degree of authority over you that he had while he was your CO, although he still retains the military authority that all seniors have over subordinates. As a PO1, you will have some degree of positional authority; as a CPO, you will have even

more. When exercising your authority, remember that it is positional—it is the rate you have, rather than the person you are, that gives you this authority.

Training

As a PO1 or CPO, you will have regular and continuing responsibilities for training others. Even if you are lucky enough to have a group of subordinates who are all highly skilled and well trained, you will still find that training is necessary. For example, you will always be responsible for training lower rated personnel for advancement in rating. Also, some of your best workers may be transferred; and inexperienced or poorly trained personnel may be assigned to you. Or a particular job may call for skills that none of your personnel have. These and similar problems require that you be a training specialist—one who can conduct formal and informal training programs to qualify personnel for advancement in rating, and one who can train individuals and groups in the effective execution of assigned tasks.

In using this training course, study the information from two points of view. First, what do you yourself need to learn from it? And second, how would you go about teaching this information to others?

Training goes on all the time. Every time a person does a particular piece of work, some learning is taking place. As a supervisor and as a training expert, one of your biggest jobs is to see that your personnel learn the RIGHT things about each job so that they will not form bad work habits. An error that is repeated a few times is well on its way to becoming a bad habit. You will have to learn the difference between oversupervising and not supervising enough. No one can do his best work with a supervisor constantly supervising. On the other hand, you cannot turn an entire job over to an inexperienced person and expect him to do it correctly without any help or supervision.

In training lower rated personnel, emphasize the importance of learning and using correct terminology. A command of the technical language of your rating enables you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his rating is definitely at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the examinations for advancement in rating. To train others in the correct use of technical terms, you will need to be very careful in your own use of words. Use correct terminology and insist that personnel you are supervising use it too.

You will find the Record of Practical Factors, NavPers 760, a useful guide in planning and carrying out training programs. From this record, you can tell which practical factors have been checked off and which ones have not yet been done. Use this information to plan a training program that will fit the needs of the personnel you are training.

On-the-job training is usually controlled through daily and weekly work assignments. When you are working on a tight schedule, you will generally want to assign each person to the part of the job that you know he can do best. In the long run, however, you will gain more by assigning personnel to a variety of jobs so that each person can acquire broad experience. By giving people a chance to do carefully supervised work in areas in which they are relatively inexperienced, you will increase the range of skills of each person and thus improve the flexibility of your working group.

Working With Others

As you advance to PO1 or CPO, you will find that many of your plans and decisions affect a large number of people, some of whom are not even in your own rating. It becomes increasingly important, therefore, for you to understand the duties and the responsibilities of personnel in other ratings. Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of other ratings, and plan your own work so that it will fit into the overall mission of the organization.

Keeping Up With New Developments

Practically everything in the Navy—policies, procedures, publications, equipment, systems—is subject to change and development. As a PO1 or CPO, you must keep yourself informed about changes and new developments that affect you or your work in any way.

Some changes will be called directly to your attention, but others you will have to look for. Try to develop a special kind of alertness for new information. When you hear about anything

new in the Navy, find out whether there is any way in which it might affect the work of your rating. If so, find out more about it.

SOURCES OF INFORMATION

As a PO1 or CPO, you must have an extensive knowledge of the references to consult for accurate, authoritative, up-to-date information on all subjects related to the military requirements for advancement and the professional qualifications of your rating.

Some of the publications mentioned here are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, make sure that you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been made.

BUPERS PUBLICATIONS

Following are some BuPers publications which will be beneficial during your study for advancement in rating:

Basic Handtools, NavPers 10085-A. You need to understand the procedure for properly using the tools discussed in this text.

Standard First Aid Training Course, NavPers 10081-A. As a shop superintendent, you are responsible for administering first aid; this course gives the procedures and methods.

OTHER NAVY PUBLICATIONS

Other government publications which will be valuable to you in your work as an Instrumentman are:

Bureau of Ships Technical Manual (NAVSHIPS 250). One chapter in this publication pertains to ship control equipment which you must repair. Another chapter deals with various mechanical measuring instruments, and this information will be helpful. NOTE: Be sure the information you get is CURRENT.

Service Manual for Jones Tachometers (NAVSHIPS 365-0163). This manual thoroughly explains the mechanisms of Jones tachometers and gives detailed instructions for repairing them (including calibration).

Bureau of Ships Navigational Instruments CONTROL MANUAL (NAVSHIPS 250-624-12). This manual discusses standard repair procedures and techniques, service tools and fixtures, test apparatus, materials used in overhaul, repair inspection standards, and so on.

Tank Capacity Gages—Liquidometers and Levelometers (NAVSHIPS 387-0276). This manual explains how to install, repair, overhaul, and calibrate levelometers and liquidometers. You should always have this manual available when you repair these instruments.

COMMERCIAL PUBLICATIONS

Manufacturers of equipment purchased by the Navy provides technical manuals (by models) which explain how to service, repair, and overhaul the machines and/or instruments. These manuals are for typewriters, adding machines, calculators, cash registers, gages and meters, dial indicators, tachometers, addressographs and graphotypes, watches, and clocks. Always use the technical manual for the machine on which you perform work. Procure replacements through your division officer or the education officer.

NAVY TRAINING FILMS

A selected list of training films for use by Instrumentmen is in Appendix I of Instrumentman 3 & 2, NavPers 10193-B. Other films which may be of interest to you are listed in the United States Navy Film Catalog, NavPers 10000 (Revised).

ADVANCEMENT OPPORTUNITIES FOR PETTY OFFICERS

Making chief is not the end of the line as far as advancement is concerned. Proficiency pay, advancement to E-8 and E-9, and advancement to commissioned officer status are among the opportunities that are available to qualified petty officers. These special paths of advancement are open to personnel who have demonstrated outstanding professional ability, the highest order of leadership and military responsibility, and unquestionable moral integrity.

PROFICIENCY PAY

The Career Compensation Act of 1949, as amended, provides for the award of proficiency pay to designated enlisted personnel who possess special proficiency in a military skill. Proficiency pay is given in addition to your regular

pay and allowances and any special or incentive pay to which you are entitled. Enlisted personnel in pay grades E-4 through E-9 are eligible for proficiency pay. Proficiency pay is allocated by ratings and NECs, with most awards being given in the ratings and NECs which are designated as critical. The eligibility requirements for proficiency pay are subject to change. In general, however, you must be recommended by your commanding officer, have a certain length of time on continuous active duty, and be career designated.

ADVANCEMENT TO E-8 and E-9

Chief petty officers may qualify for the advanced grades E-8 and E-9 which are now provided in the enlisted pay structure. These advanced grades provide for substantial increases in pay, together with increased responsibilities and additional prestige. The requirements for advancement to E-8 and E-9 are subject to change, but in general include a certain length of time in grade, a certain length of time in the naval service, a recommendation by the commanding officer, and a sufficiently high mark on the servicewide examination. The final selection for E-8 and E-9 is made by a regularly convened selection board.

Examination Subjects.—The examinations for pay grades E-8 and E-9 are divided into three sections: professional knowledge, supervisory knowledge, and common knowledge. The professional knowledge section is designed to measure, at an advanced level, a candidate's knowledge of his particular rating. Personnel who prepare these questions are guided by the Manual of Qualifications for Advancement in Rating and the related bibliography in Training Publications for Advancement in Rating. Pertinent publications from among those listed in the military requirements section of NavPers 10052 are used as sources of the supervisory knowledge section. The common knowledge section contains questions designed to test the candidate's arithmetical, mechanical, and verbal reasoning capabilities. Questions for this section are drawn from basic mathematics, physics, and vocabulary development texts.

Sources of Information.—In addition to the titles listed above, the following publications, distributed to Navy libraries and Educational Services offices, will assist the candidate for E-8 and E-9 in preparing for the examinations: College Entrance Examinations Study Material (limited distribution); High School Subjects Self Taught Book (Navy-wide distribution); Basic Mathematics (Navy-wide distribution); Mathematics Review (Navy-wide distribution); popular texts on psychology (Navy-wide distribution); various USAFI texts (Navy-wide distribution); vacabulary development books (limited distribution).

ADVANCEMENT TO COMMISSIONED OFFICER

The Limited Duty Officer (Temporary) Program provides a path of advancement to commissioned officer status for outstanding petty officers of the Regular Navy. LDOs are limited, in their duty, to the broad technical fields associated with their former rating.

Education, length of service, and maximum age limits are usually specified in the requirements for advancement to LDO. However, these requirements vary according to circumstances, and the program is in a period of transition. If you are interested in advancing to LDO, ask your division officer for the latest requirements that apply to your particular case.

Another path of advancement to commissioned officer status is provided by the Integration Program. Enlisted personnel possessing the required qualifications may be appointed under this program to the grade of ensign in the Line, Supply, or Civil Engineer Corps of the Regular Navy. Education, length of service, and maximum age limits are included in the requirements for eligibility under this program. Eligibility requirements for this program, as well as for the other programs discussed here, are subject to change.

CHAPTER 2

THE REPAIR DEPARTMENT

As an Instrumentman 1 or a Chief Instrumentman in charge of an instrument shop, you have a definite need for a thorough understanding of department and division organization and administration aboard ship. You also need to know how your own shop should be organized and administered.

A department in a ship's organization is a segment of the organization; a division is a component of a department. A department is created for the sole purpose of carrying out specific responsibilities, such as engineering; a division is responsible for the execution of a definite portion of a department's mission. For the sake of better administration, a division is further divided into sections with specific functions. The size of a division varies from one or two members to over one hundred members.

A ship's organization and regulation manual gives the ship's administrative organization; and it contains the administrative and operational bills, routine work details, and other details of duty to be performed by or assigned to the ship's divisions. An organization and regulations manual is in reality a general directive with the force and effect of Navy regulations.

REPAIR DEPARTMENT ORGANIZATION

The primary function of the repair department is the repair and maintenance of ships (and equipment) assigned by higher authority. A secondary mission of the repair department is the repair of own ship's machinery and equipment.

Study illustration 2-1, which gives the administrative organization of the repair department in the USS Sierra (AD-18). Observe that your division (Ordnance Systems Repair) on this particular ship contains five shops besides the instrument shop, in which you perform your primary duties: NOTE: On some repair ships and tenders the instrument shop may be in the R-2 division. The administrative organization of the repair department on this ship is typical for repair ships and tenders, but it is not standard on all of them.

REPAIR OFFICER

As the administrative head of the repair department, the repair officer is responsible to the commanding officer for the accomplishment of repairs and alterations to ships made available for such work by competent authority, and for such other duties as may be assigned. Specifically, he is responsible for:

1. Preparing estimates of funds required for the operation of his department.
2. Planning and scheduling work for his department.
3. Inspecting work in progress to ensure its timely and satisfactory completion.
4. Establishing and operating an adequate job order system.
5. Maintaining a record of charges for materials used in effecting repairs.

ASSISTANT REPAIR OFFICER

Authority for the assignment of assistant department heads, when required, is given in Article 0906 of U. S. Navy Regulations. Department heads are responsible for the performance of duty by assigned assistants.

Responsibilities of assistant department heads are listed in Article 0907 of Navy Regulations. These responsibilities include: (1) supervision and training of assigned personnel; (2) care and use of equipage and stores charged to them; (3) upkeep and cleanliness of spaces; (4) maintenance of pertinent records; (5) preparation of required reports; and (6) such other duties as may be assigned.

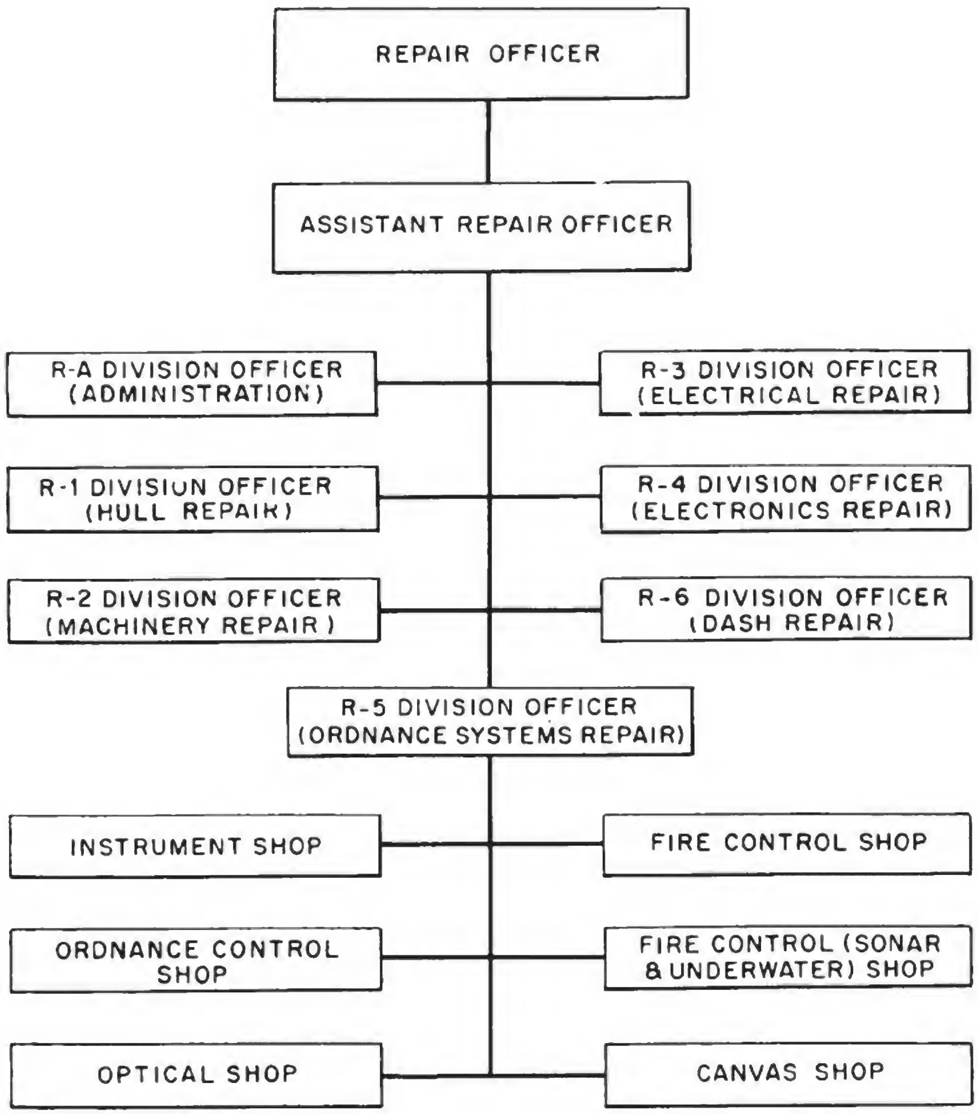

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Figure 2-1.—Administrative organization of the repair department in the USS Sierra (AD-18).

In addition to the duties just listed, an assistant repair officer is also responsible for:

1. Administration of the repair department.
2. Reviewing of repair requests from assigned ships and assigning the requests to appropriate shops for necessary action—accomplishment of the work.
3. Administration of the R-A division, including the preparation of department correspondence.
4. Assignment of mess cooks, and management of assigned compartment(s).
5. Follow-up on work assigned to shops, to ensure timely and satisfactory completion.
6. Supervision of the preparation and final approval of a repair department watch list.
7. Inspection of shops for work procedures, work hazards, and cleanliness.
8. Handling of special requests from department personnel.

9. Review of division organization charts for balance of rated and non-rated men in each duty section.

10. Review (monthly) of division training records.

11. Performance of the duties of the repair officer during his absence.

DIVISION OFFICERS

Take another look at the repair department division listed in illustration 2-1. There are seven divisions. The assistant repair officer is the division officer of the R-A division and has yeomen assigned to help him administer the office—correspondence, records, reports, publications, instruction books, files, supplies, organization chart, maintenance of office space, and routing of work requests.

All other division officers in the department are responsible for the functions listed below their division designation on the chart. Your division (R-5) is responsible for ordnance systems repair, and it is generally comprised of six shops: optical, fire control, ordnance control, fire control (sonar and underwater), canvas, and instrument. The optical shop repairs and calibrates all types of optical equipment. The fire control shop conducts tests of electrical fire control circuits for continuity, grounds, short circuits; and it repairs, adjusts, and calibrates fire control radars.

The sonar and underwater fire control shop repairs, tests, and calibrates all types of sonars, underwater fire control systems (including fathometers) used in naval ships; provides calibrated hydrophones to tended ships for calibrating their own units; provides tended ship's personnel technical assistance for repairs to sonar equipment; accomplishes field changes; and so forth.

The optical shop repairs, calibrates, and/or collimates binoculars (7 x 50 hand-held and 20 x 120 mounted), ship's telescopes, gun sight telescopes; repairs parallel motion protractors and magnetic compasses; and so on. The canvas shop fabricates miscellaneous canvas covers and awnings and boat cloths and also upholsters furniture.

SHIP SUPERINTENDENTS

The repair officer must assign a ship superintendent to a group of ships tended alongside, and also to ships of which your repair ship is MOTHER TENDER. This superintendent is a liaison officer between your ship and tended ships, and he assists the repair officer in maintaining daily progress of work in shops. All ship superintendents are assigned to the R-A division.

A ship superintendent is also responsible to the repair officer for the following:

1. Assigning shop responsibility and job order numbers to work requests.

2. Preparing progress sheets for job orders and maintaining files of all work requests received.

3. Routing of work requests to division officers 10 to 12 days prior to the commencement of an availability, when possible.

4. Collecting for review by the repair officer prior to the arrival conference ALL work requests on which division officers made comments.

5. Noting changes in work requests agreed on at the arrival conference and correcting repair division officers' copies.

6. Visiting each repair shop daily and consulting with shop supervisors and division officers about their work, and recording on the progress sheet for each job order the percentage of completion.

7. Visiting each tended ship daily and advising the ship's liaison officer (normally the engineer officer) about the progress being made on each job and notifying him when to pick up the completed work. (He must also check work requests of ships NOT alongside and notify them when to pick up completed work.)

8. Advising the repair officer immediately when a tended ship has a complaint of unsatisfactory or incomplete work, and informing him when a tended ship's personnel fail to cooperate with the repair ship's personnel.

9. Advising the repair officer immediately when urgent jobs are not progressing satisfactorily in shops, or when jobs are delayed because of lack of material.

10. Finding out when ships are scheduled for assignment to his repair ship, and advising his repair officer two weeks prior to the availability date.

11. Keeping work requests complete—manhour data, name and rate of shop supervisor, person who performed the work, name and rank/rate of tended ship's inspector who inspected and accepted the work, and the date. NOTE: Initials in lieu of a name are unacceptable.

12. Discussing with the repair officer all problems connected with the repair work, and doing such other work as requested.

DUTY REPAIR OFFICER

A duty repair officer is a repair department officer assigned to serve in this capacity from 0800 to 0800 the following day. His responsibilities include the following:

1. Assuming the duties of the repair officer and assistant repair officer in their absence.
2. Inspecting frequently, after normal working hours, repair department working and living spaces.
3. In port, making 2000 reports to the command duty officer relative to the security of the department, the men and boats away from the ship on repair work, and the approximate time the shops will secure.
4. Reporting to the repair officer, or the assistant repair officer, prior to 1600 on work days for briefing of repairs to be accomplished after normal working hours.
5. Approving, expediting, and supervising emergency repair work after normal working hours.
6. Calling the repair officer when necessary, and performing all assigned duties.

DUTY REPAIR CHIEF PETTY OFFICER

Each day one chief petty officer from the repair department is assigned the duties of duty repair chief. His tour of duty commences at 0800 and ends at 0800 the following day. He must:

1. Assist the duty repair officer in the performance of his duties.
2. Muster the watch section immediately after quarters, and determine at this time whether men appointed to watches were instructed concerning their duties. NOTE: Watches and duties involved are listed in the Repair Department Organization and Regulations Manual. He must then have the men initial alongside their names on the watch sheet to indicate that they understand their duties and know the time and place of their watch assignments.
3. Inspect berthing spaces and repair department shop spaces on an AS NECESSARY basis (and after normal working hours) for cleanliness, safety and fire hazards, locked tool cabinets and storerooms; and he must take prompt action whenever necessary by calling the division duty petty officers to have deficiencies corrected.
4. Make inspections of repair department living quarters at reveille and see that duty division petty officers hold reveille promptly.
5. Report to the duty repair officer prior to taps and accompany him in making his inspection of repair department spaces. Deficiencies must be corrected on the spot. Unsatisfactory conditions must be reported by memorandum to the repair officer.

DUTY DIVISION PETTY OFFICER

Each day one LEADING petty officer from each division's duty section is assigned as duty division petty officer. On normal work days, his tour lasts from the end of the normal work day until 0800 the following day. On Saturdays, Sundays, and holidays, his tour of duty lasts from 0800 to 0800. His duties include:

1. Inspecting division shop spaces at the end of working hours for security, and making a report to the duty repair officer at 1600 and 1900.
2. Informing the duty repair officer concerning the progress of urgent repair work.
3. Seeing that only authorized personnel use machinery, and that workers are complying with existing orders, instructions, and safety precautions.
4. Making certain that no fire hazard or accident hazards exist in berthing and shop spaces.
5. Ensuring that tools found adrift are returned to toolrooms and that the toolrooms are locked.
6. In the absence of the shop supervisor, taking charge of the repair work of his division after normal working hours.

DUTY POLICE PETTY OFFICER

In compliance with ship's instructions, generally, each division officer designates a senior petty officer (normally a PO1) as division police petty officer and others as duty section division police petty officers. When underway, the duties of the senior division police petty officer are continuous; when in port, his duties are from 0800 to 0800. On week days, the duties of the duty section division police petty officer commence at the end of working hours and end at 0800 the following morning. On Saturdays,

Sundays, and holidays, his duties commence at 0800 and end at 0800 the following day.

The division police petty officer acts as Master-at-Arms for the division, and reports directly to the CMAA. The duty section division police petty officer acts as Master-at-Arms for the division during hours of liberty, and reports directly to the Duty Master-at-Arms. The Chief Master-at-Arms issues badges to the division police petty officers, who must wear them when on duty. The division police petty officer must enforce the ship's orders, instructions, Navy Regulations, and effective orders within his own division. The division police petty officers must see that men of their division turn into their bunks at taps and turn out at reveille. Each division police petty officer must inspect his berthing spaces, heads, and washrooms for compliance with cleanliness regulations.

REPAIR DIVISION SHOP SUPERVISOR

The leading petty officer in each shop is generally the shop supervisor and shop safety engineer. His duties are what yours will be when you are the leading petty officer in an instrument shop, and they include:

1. Planning, scheduling, and maintaining (under the division officer) a program chart of the shop work load.
2. Expediting the completion of work requested, and ensuring by frequent inspections that repairs are accomplished in a satisfactory manner.
3. Advising your division officer relative to production lags.
4. Maintaining order and discipline in the shop.
5. Keeping shop equipment clean and in excellent condition, and shop spaces free from fire and accident hazards.
6. Posting operating and safety instructions on all portable and stationary shop machinery and tools.
7. Ensuring that shop personnel are proficient in the operation of ship equipment and tools before they are assigned (authorized) to use them.
8. Enforcing safe work habits, taking every precaution to prevent injury to personnel and damage to shop equipment because of carelessness and/or improper operation; and if necessary, removing a machine operator from a job.
9. Ensuring that each machine operator takes proper care of and keeps his machine clean.
10. Signing custody receipts for tools and equipment issued your shop, as required; and keeping records of tools issued and taking inventories as directed.
11. Making certain that tool room custodians keep tools in good condition and that they requisition replacements for worn or broken tools. NOTE: In order to maintain proper accountability for tools, keep a check-out and a check-in sheet on tool issues and receipts.
12. Making recommendations on special requests submitted by subordinates in the shop. (Explain reasons for disapproval to the division officer.)
13. Having the person in charge of a job sign his name in the block provided on the work request (when he completes the job). NOTE: Sign your own name also to indicate that you inspected the work and found it satisfactory.
14. Informing the division duty repair petty officer at the end of the working day of urgent work which must be completed during the night.
15. Inspecting shop spaces and making 1600 and 1900 securing reports to the division officer underway. (This report must contain the following: security of shop spaces, men working on special jobs, and the time when the men are expected to secure from work.)

INSTRUMENT SHOP ADMINISTRATION

As an Instrumentman 1 or a Chief Instrumentman, you will be the superintendent of the instrument shop, responsible to the division officer for its administration. The word ADMINISTRATION includes everything you must do in accomplishing satisfactorily all work assigned your shop, including: (1) procurement of equipment and supplies, (2) cleanliness and sanitation of spaces, (3) training of personnel, (4) accomplishment of acceptable work within the alloted time, (5) supervising Instrumentmen, (6) preparing information required for making surveys, (7) coordinating the work of your shop with all cognizant persons, and (8) performing assigned duties and responsibilities.

Before you can qualify for advancement in rating to an Instrumentman 1, you must know how to fill out equipment failure (casualty analysis) reports; prepare requisitions for tools, repair parts, and consumable supplies; instruct

personnel in an instrument shop; and lock the balance wheel of a ship's chronometer in preparation for shipment to a chronometer pool.

In order for you to qualify for advancement in rating to Chief Instrumentman, you must be able to prepare inter-shop job orders and work requests, and written information necessary for procuring or surveying equipment. You must also know the equipment and tool requirements of office machine, watch and clock, and gage and meter repair shops; how to plan repair work assigned an instrument shop; and the methods and procedures to follow for supervising the professional training of personnel in an instrument shop. Another thing you MUST know is the meaning of measurement standards for pressure, temperature, flow, and linear measurements.

The discussion on the following pages of this chapter is designed to provide you with the information you need in order to qualify for advancement in rating, in addition to what you have already learned through your study of Instrumentman 3 & 2, NavPers 10193-B; Basic Military Requirements, NavPers 10054-A; and Military Requirements for Petty Officer 1 & C, NavPers 10057-A. An attempt is made here to hold to a minimum a repetition of information presented in those training manuals.

EQUIPMENT AND SUPPLIES

You can find out from the Coordinated Shipboard Allowance List (COSAL) what equipment and tools are authorized your shop. As you learned through previous study, you should keep (maintain) a separate record on each piece of equipment in the shop. This record should show the age of the equipment, repairs and/or changes made on it, and all important information. All equipment must be maintained in such manner that it is always in excellent operating condition.

The training of Instrumentmen in the proper use of equipment in the shop is your responsibility. Provide the training essential for each man before you authorize him to use a machine. An improperly trained machine operator can soon damage an expensive machine. A careless or indifferent attitude by an Instrumentman relative to the operation of a machine should not be tolerated. Responsibility for proper care and usage of shop equipment actually rests with the shop supervisor, the person responsible for training, and not with the operators.

When a piece of equipment is beyond economical repair, prepare the written information necessary for a report of survey and submit it to your division officer for appropriate action. Unsatisfactory and/or inoperative equipment should be replaced as soon as practicable.

Perpetual inventories should be maintained on consumable supplies, and replenishments should be requisitioned early enough to allow adequate lead time for them to arrive in time aboard your ship. The procedure for filling out and submitting requisitions is fully explained in the training manuals on military requirements for petty officers.

TRAINING AND SUPERVISION

Training and supervisory responsibilities are generally the same for personnel with similar ratings in all shops. You should not forget, however, that training is an individual matter; every person learns at his own rate, in accordance with his intelligence, previous training and experience, and his motivation. No two individuals learn in the same manner or at the same rate. Training is also continuous.

Before you can do the best job of training your men, you must learn everything (within reason) that you can about them. Study the previous record of each Instrumentman to find out something about his intelligence, training, and experience. Then have a talk with him in private. Let him talk first, to get THINGS off his mind; then SELL yourself and your shop to him. Show your interest in him; and let him know how important he is as a member of your team. If you use this approach, training will be much easier; and the work from your shop will be better and more productive. Best results in handling personnel can usually be accomplished through calmness and mutual understanding; but always be fair and honest with each person. Then you will have the respect of all—you will not have to earn it.

One important aspect of training is on-the-job instruction; and this must be individualized for each person and each job. Training of an Instrumentman in the repair of a cash register, for example, or anything new to him, must be accomplished on an individual basis and by degree. If a man knows how to repair one watch or electric typewriter of a specific make and model, of course, he will know something about repairing similar machines of different makes and models.

The best way to teach a person by the on-the-job method is to demonstrate slowly and methodically, with appropriate explanations, the procedure for doing a certain thing. Then repeat the same thing and have the trainee explain to you how to do it. Then have the trainee do the work while you supervise him and correct deficiencies in his procedure and/or technique. From this point on, much practice in doing the work leads to proficiency.

It would seem that a trained person (Instrumentman) should be able to perform his duties without supervision; unfortunately, this is seldom true. Even the best Instrumentman may lose some interest, or develop bad habits, in doing his work; so you should give some supervision to the work of each man every day. Your presence in the shop and your contacts with your men indicate your interest in them and their work; your comments make them feel good and encouraged. Remember that a friendly attitude and a keen interest go a long way in motivating your men to do more and better work. Good men seldom let a GOOD supervisor down. Remember, too, that your conversation, the pitch of your voice, and your whole personality set the tone of your shop. It is never better than the supervisor himself.

If it is ever necessary to counsel an Instrumentman, counsel him in private. It is best, however, to PRAISE him before others. Do not make an Instrumentman feel bad by BAWLING HIM OUT in the presence of other Instrumentmen.

In a word, the best shop supervisor is one who understands each individual in his shop and knows how to utilize his abilities for maximum benefits of the shop and the repair department.

TECHNICAL MANUALS AND PUBLICATIONS

Your repair department will have in its library important publications pertaining to its operation, including the Ship's Organization and Regulations Manual and the master Repair Department Organization and Regulations Manual. Your division office will also have copies of these publications, and others dealing with the division's organization and administration.

You should keep in your shop library all naval publications which pertain to your work. These include:

1. Bureau of Ships Technical Manual (NAVSHIPS 250).
2. Service Manual for Jones Tachometers (NAVSHIPS 365-0163).
3. Bureau of Ships Navigational Instruments Control Manual (NAVSHIPS 250-624-12).
4. Tank Capacity Gages–Liquidometers and Levelometers (NAVSHIPS 387-0276).

You need in your library also such publications as TM 9-1575 (Army), which is a manual on watches and clocks; T.O. 33-1-19 (USAF), which is a technical manual on maintenance and repair of pressure, compound, and vacuum gages; and manufacturers' technical manuals for all makes and models of instruments on which you perform maintenance in the shop.

MEASUREMENT STANDARDS

Measurement standards involve what is known as METROLOGY, the science of measurement (including the development of standards and systems for absolute and relative measurements). When you check the accuracy of measurement of a pressure gage, for example, you check it against a STANDARD, a pressure gage of KNOWN accuracy.

Your division will have publications which explain measurement standards, so the following discussion is limited to definitions of measurement terms, different measurement standards, and the meaning of these standards to an Instrumentman.

Some of the terms applicable to measurement standards are:

1. Calibration.—Calibration is the process whereby measurement standards or equipment of unknown accuracy are compared with measurement standards or equipment of known accuracy and then adjusted in order to ensure operation within required specifications.

2. Measurement Equipment.—Measuring equipment consists of tools and test equipment developed and tested to provide a known reference for comparison with, or verification of, performance characteristics of measuring instruments (pressure gages, thermometers, etc.).

3. Standard (Measurement).—A measurement standard is equipment which is established as an authorized or recognized measure, especially one which serves as the basic means for measuring the accuracy of precision instruments.

4. Calibration Laboratory.—A calibration laboratory provides calibration and repair services for measurement equipment used by activities engaged in research, development, test, evaluation, production, quality assurance, maintenance and operation of weapon systems, equipment, and other Department of Defense material.

5. Standards Laboratory.—A standards laboratory provides calibration services for certifying the measurement standards of calibration laboratories. These laboratories serve as the highest level laboratores of the military services and they obtain certification of their measurement standards directly from the National Bureau of Standards, which establishes national primary standards and provides calibration services to the entire country.

6. Type I Laboratory.—A Type I laboratory is a Department of Defense laboratory which obtains calibration services from the National Bureau of Standards and provides calibration services within a designated geographical area to the next lower echelon (Type II) laboratories.

7. Type II Laboratory.—A Type II laboratory obtains calibration services direct from a Type I laboratory and provides services within a designated geographical area to the next lower echelon (Type III) laboratories.

8. Type III Facility (Laboratory).—A Type III laboratory obtains calibration services from a Type II laboratory and provides calibration (or calibration and repair) services to activities which use working standards and test equipment in the development, testing, maintenance, overhauling, and operating of weapon systems or associated prime equipment.

Because measuring equipment drifts out of alignment and/or deteriorates, it must be calibrated periodically to determine the validity of measurement of its indicating, sensing, or control devices. Calibration intervals, in fact, are prescribed for all Department of Defense measuring devices designed and used for accurate measurement.

If measuring equipment must be repaired, it must also be calibrated. The standards used for calibration after repair are the same as those needed for periodic calibration; and for this reason, repair and calibration are combined at those facilities which have repair responsibility.

Type III calibration facilities are LOCAL facilities responsible for the repair and calibration of test equipment on a regularly scheduled basis. These naval facilities include: shipyards, air stations, ammunitions depots, submarine bases, research activities, supply centers, and various repair ships and tenders.

SHIPMENT OF CHRONOMETERS

Before you package a chronometer for shipment to a chronometer pool, you MUST lock the balance wheel to protect it from vibration and possible damage in transit. Figure 2-2 shows how to lock the balance wheel of a chronometer. Observe the direction (indicated by arrows) to turn the balance brake lock wrench to LOCK and to UNLOCK the balance wheel. Note also the balance brake lock screw which the brake lock wrench operates to move the balance wheel brake arm into the locked or unlocked position. The illustration shows the brake arm in the LOCKED position.

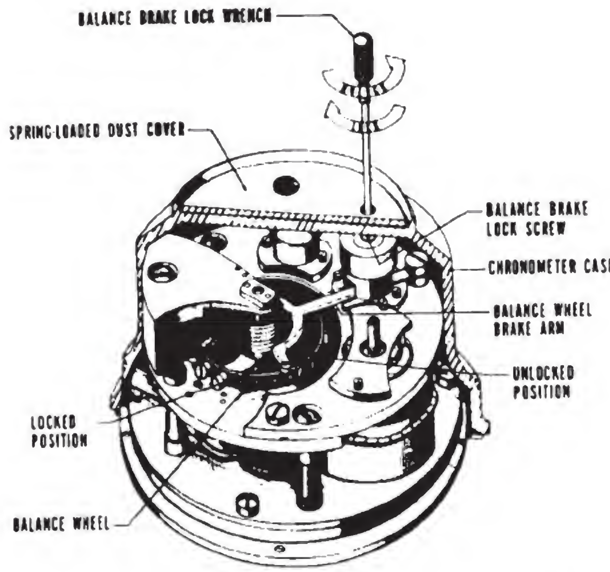

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Figure 2-2.—Procedure for locking the balance wheel of a chronometer.

The procedure to follow when you lock the balance wheel of a chronometer is as follows:

1. Grasp firmly the knurled edge of the glass bezel and invert the chronometer.

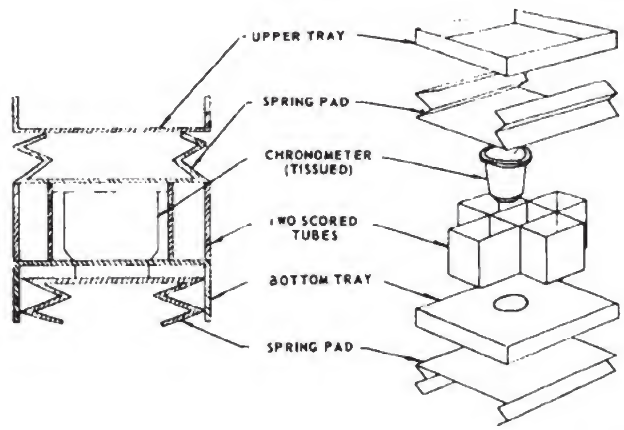
2. Insert the balance brake lock wrench (in the gimbal box) into the small hole in the dust cover and rotate the cover clockwise until the wrench engages the balance brake lock screw.

3. Rotate the wrench in a clockwise direction (about 1 1/2 turns) in order to move the

balance wheel brake arm as required to lock the balance wheel. Then remove the wrench and gently release the dust cover.

The procedure for packaging a chronometer in a metal shipping container is illustrated in figure 2-3. The steps in the packaging procedure are:

1. Put one spring pad (spring sections down) in the bottom of the container, as illustrated.
2. Place the bottom tray on top of the bottom spring pad. Note the hole in the center of this tray.
3. Put the cardboard composed of interlocking cells on top of the bottom tray.
4. Wrap the chronometer with soft tissue paper and insert it in the center cell of the cardboard section on top of the bottom tray. CAUTION: Be sure the tapered bottom of the instrument is securely fitted in the hole in the bottom tray, to prevent the instrument from moving.
5. Put the top spring pad (spring sections up) on top of the cubed section which contains the chronometer.
6. Place the upper tray (flat side down) on top of the upper spring pad.
7. Put the top on the metal container and secure it.
8. Properly identify the contents of the can (unless stamped on already).



91.2

Figure 2-3.—Packaging a chronometer for shipment.

SHOP BULLETIN BOARD

You should have a bulletin board in your shop for posting all notices and instructions. If it is properly used, a bulletin board is a valuable training aid, and also a morale builder. Interested workers generally read everything posted on a bulletin board.

Your bulletin board should contain one section identified by the word DAILY, or DAILY NOTICES. In this section you should post daily department and division notices and bulletins. Another section of the bulletin board should be captioned SHOP INSTRUCTIONS, in which you should put your own bulletins and instructions. A third section of the bulletin board should be for notices and bulletins of indefinite tenure; and still another section of the board should be captioned MISCELLANEOUS. In the last section you should post clippings of interest, movie information, coming events, church notices, and so on. Safety precautions and the Watch, Quarter, and Station Bill for the division should also be posted in this section, unless your board is large enough to have a separate section for them.

If you use this means of disseminating information, through a sectionalized bulletin board, you will keep your men informed and interested in what is going on in the shop and in the department. The sections will help you to keep your bulletin board CURRENT but not CLUTTERED UP. CAUTION: Remove bulletins and notices which have expired.

CHAPTER 3

MANUAL TYPEWRITERS

Before you can qualify for advancement in rating to Instrumentman first class, you must know how to overhaul Remington, Royal, Smith-Corona, and Underwood typewriters. You must also know how to analyze and remedy casualties to these machines, including portable typewriters.

The word OVERHAUL means to check thoroughly for and make necessary repairs and adjustments to a machine, including the replacement of parts. When a mechanic, for example, says he overhauled a motor or a typewriter, he means that he disassembled the machine, cleaned and inspected parts, replaced defective or broken parts with new ones, reassembled, oiled, and adjusted the machine until it ran to his liking. In other words, he put the machine in practically new working condition, exactly as you must do when you overhaul a typewriter.

You learned in Instrumentman 3 & 2, NavPers 10193-B, how to disassemble, clean, reassemble, and oil an Underwood standard typewriter; but you did not learn many details about repairing and adjusting it. Because of the amount of material required to cover an overhaul job on a typewriter, space in this text does not permit a discussion of the procedure for all makes and models. The only thing that can be done, therefore, is to discuss the procedure for overhauling one make of standard typewriter (with references to major differences in other makes and models) and refer you to other manufacturers' technical manuals for differences in procedure for overhauling their machines. The mechanisms of standard typewriters are similar, but there are some differences which you should know.

Figure 3-1 shows a Royal standard typewriter with the top cover removed, and with the nomenclature of visible parts listed. When you finish studying this illustration, take a look at figure 3-2, which gives a front view of a standard Smith-Corona typewriter, with some of the nomenclature listed. Compare the nomenclature of this machine with the Royal, and also note the differences in the location of various parts.

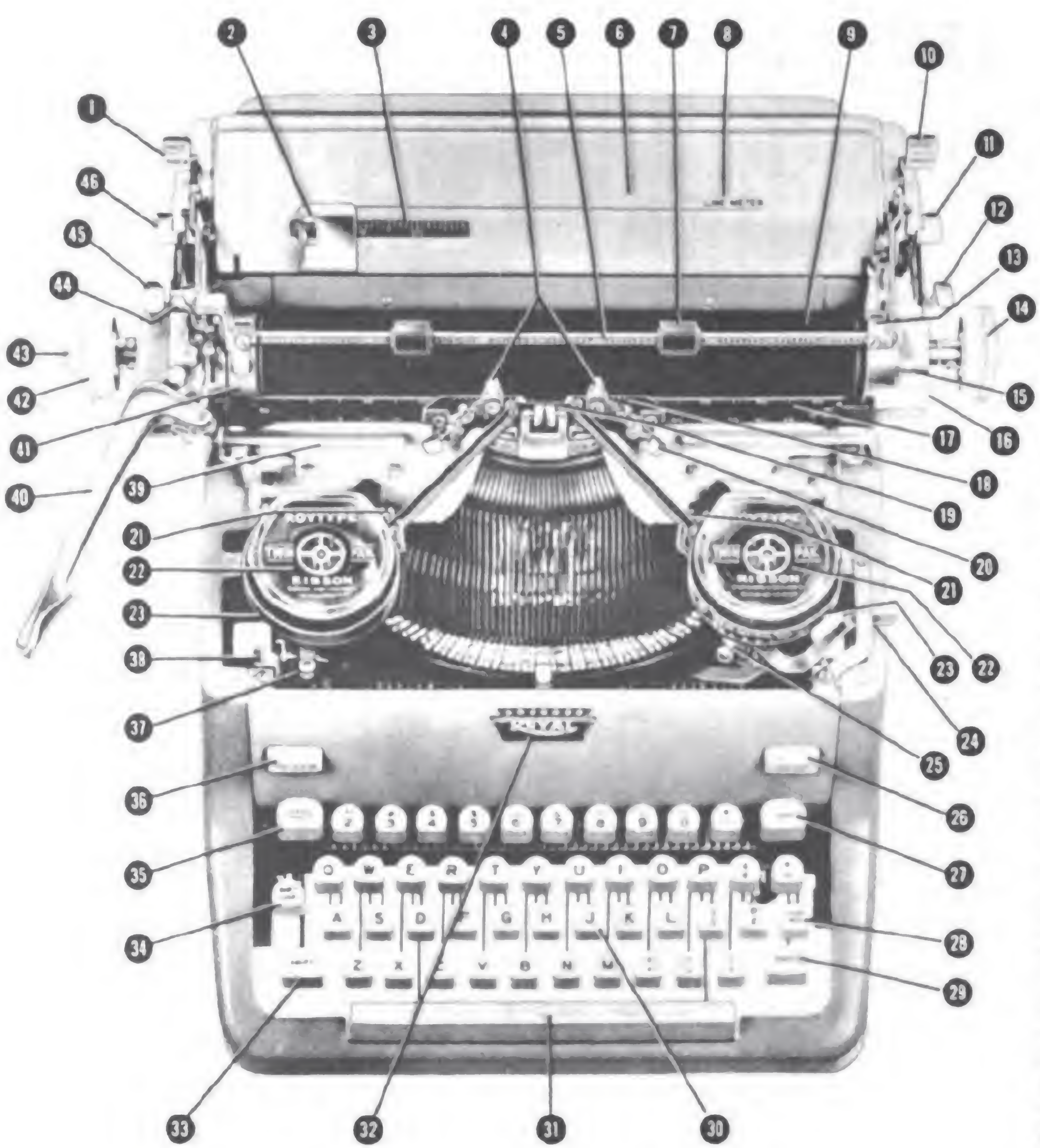
REMINGTON STANDARD TYPEWRITER

The following discussion covers the overhaul and repair of a Remington standard typewriter, which was illustrated in Instrumentman 3 & 2, NavPers 10193-B. The principle of operation of a standard manual typewriter was also explained in that text, so it is not repeated here. Emphasis in this chapter is placed on the operation of different mechanisms and parts in the Remington machine, analyzing troubles, effecting repairs, and making adjustments. The different mechanisms and parts are discussed first, so that you will understand what they are and where they fit when disassembly is considered, and also when you make repairs and adjustments.

TYPE BAR MECHANISM

If you know the nomenclature of important parts in a mechanism, and all mechanisms in a typewriter, you can follow the action of the parts better, and develop a better understanding of the role they play in the operation of the machine. Keep this thought in mind as you study the type bar mechanism illustrated in figure 3-3, and do the same thing when you study all other mechanisms. Learn the nomenclature as you study each illustration.

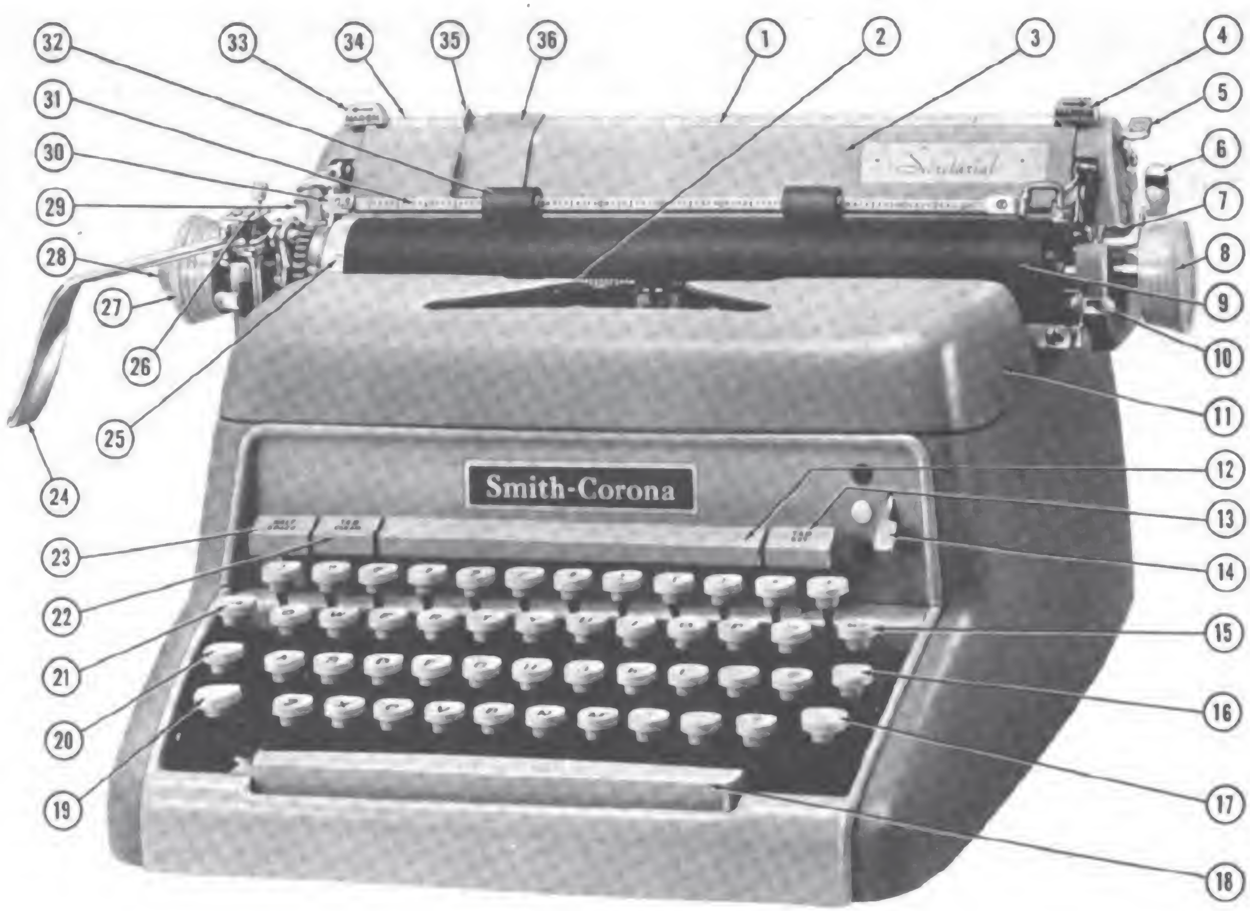
When a typist strikes a key top, the key-lever to which it is secured moves downward and pulls the type bar bellcrank link forward and down. As the type bar bellcrank link moves forward, it pulls the type bar bellcrank top forward, and also the type bar bellcrank link attached to it. The type bar bellcrank link, connected with the type bar at its base, pivots



1. "Magic" Margin (left)
2. Paper Guide
3. Paper Guide Scale
4. Card Holders
5. Paper Lock Scale
6. Paper Table
7. Paper Lock Roller
8. Line Meter Aligner
9. Removable Cylinder
10. "Magic" Margin (right)
11. Paper Release Lever
12. Right Carriage Release
13. Automatic Paper Lock
14. Right Cylinder Knob
15. Cylinder Collar
16. Cylinder Release Lever
17. Full Length Cylinder Scales
18. Card & Writing Line Scales
19. Twin-Pak Ribbon Carrier
20. Card Holder Release
21. Ribbon Guides (left and right)
22. Twin-Pak Ribbon (left and right)
23. Twin-Pak Ribbon Holders (left and right)
24. Ribbon Color and Stencil Control
25. "Touch Control" Lever and Dial
26. Tab Set Key
27. Tabulator Key
28. Margin Release Key
29. Right Shift Key
30. Finger Flow Keys
31. Speed Spacer
32. Presto-Magic Top Release
33. Left Shift Key
34. Shift Lock
35. Back Space Key
36. Tab Clear Key
37. Ribbon Reverse
38. Ribbon Wind Lever
39. Erasure-Protecting Shields
40. Line Space and Carriage Return Lever
41. Line Meter Indicator
42. Left Cylinder Knob
43. Variable Spacer
44. Line Space Selector
45. Left Carriage Release
46. Line Finder

61.37X

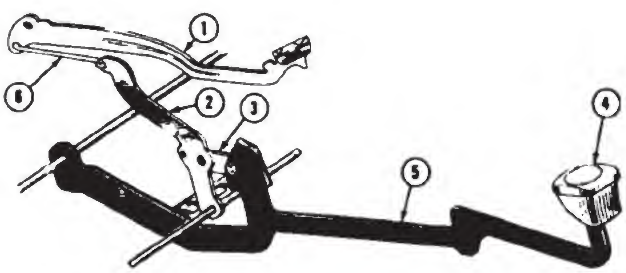
Figure 3-1.—Royal standard typewriter.



1. Paper guide scale
2. Platen scale
3. Paper table
4. Right margin button
5. Total tab clear lever
6. Paper release lever
7. Right carriage release
8. Right platen knob
9. Removable platen
10. Right platen latch
11. Ribbon spool cover
12. Tabulator bar
13. Tabulator set key
14. Ribbon color control
15. Margin release key
16. Right shift lock
17. Right shift key
18. Full-size space bar
19. Left shift key
20. Left shift lock
21. Back space key
22. Tabulator clear key
23. Half space (error control)
24. Carriage return lever
25. Page gage
26. Line space regulator
27. Left platen knob
28. Variable line spacer
29. Line retainer
30. Three-position floating paper bail
31. Paper bail scale
32. Paper bail roll
33. Left margin button
34. Automatic centering 11-inch sheet
35. Automatic centering 8 1/2-inch sheet
36. Adjustable paper guide

61.37X

Figure 3-2.—Smith-Corona standard typewriter.



1. Type bar
2. Type bar bellcrank
3. Type bar bellcrank link
4. Key top
5. Key lever
6. Type bar connecting link

61.40X

Figure 3-3.—Type bar mechanism.

the type bar on the fulcrum wire and swings it up and to the rear. This, in essence, is how the type bar mechanism functions.

ESCAPEMENT MECHANISM

The escapement mechanism consists of an escapement wheel (fig. 3-4) to which a pinion is attached; an escapement rocker body, containing the escapement loose dog and the rigid dog; and the escapement operating bail, with link and type bar universal bar (U-bar). The escapement loose dog can move laterally and vertically. An arm controls the amount of lateral travel, and the loose dog guide controls the amount of vertical travel. A spring holds the loose dog against the upper arm of the loose dog guide and to the right (facing the rear part of the machine) when it is not in contact with a tooth of the star wheel.

When the escapement mechanism is in its normal position, the escapement loose dog is in contact with a tooth of the escapement wheel which (by the meshing of its pinion wheel with the feed rack) prevents the carriage from moving.

When a type bar travels toward the platen (top rearward), the heel of the type bar contacts the U-bar which then pivots on the type bar U-bar oscillator (fig. 3-4). The type bar U-bar pivots on the type bar U-bar oscillator bracket and causes the tail of the type bar U-bar to move rearward and pivot the operating bail and roll. The operating bail then pulls the escapement trip wire forward and rocks (pivots) the escapement rocker top rearward. This action disengages the loose dog from the star wheel tooth and allows the star wheel to advance until the tooth just released is intercepted by the rigid dog. When the escape wheel moves, the tension on the carriage spring moves the carriage to the left until the tooth of the wheel is caught and held by the rigid dog. As the type bar returns to its normal position, it restores the entire mechanism to its normal rest position.

SPACEBAR MECHANISM

When the spacebar is depressed, the spacebar levers (fig. 3-5) move down and pivot the spacebar shaft toward the front of the machine, causing the rear end of the friction-fitted extension arm to move upward. As the rear end of the extension arm rises, it lifts the U-shaped connecting link, which raises the spacebar push link. The roll at the top of this link then contacts the escapement arm and rocks the escapement rocker top rearward. This action disengages the loose dog and allows the star wheel to advance to complete the escapement action.

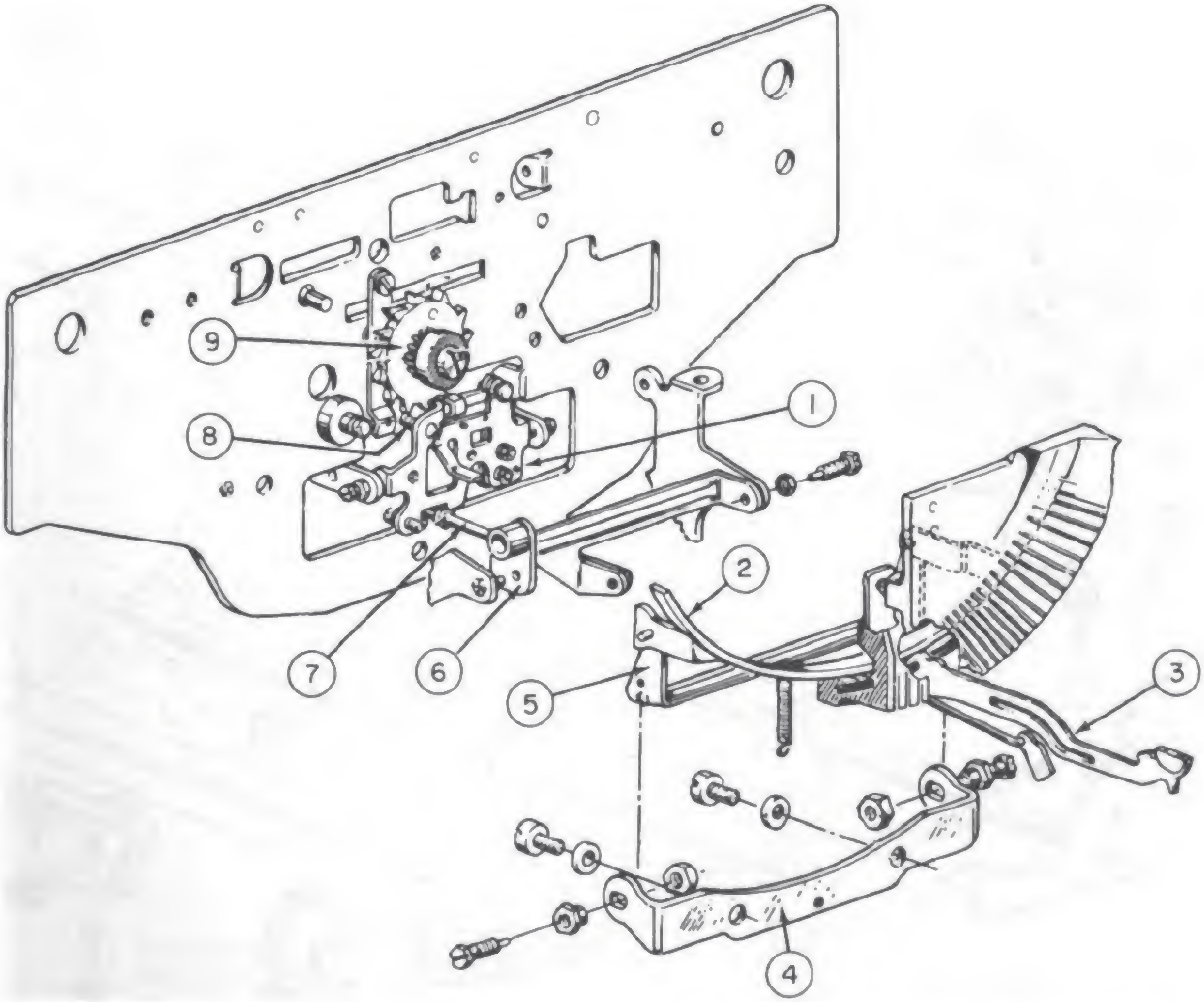
When the spacebar is released, the spring attached to the top of the U-shaped connecting link over the rear end of the extension arm on the spacebar shaft returns the spacebar mechanism to its rest position.

LINELOCK AND MARGIN RELEASE MECHANISM

Study the linelock and margin release mechanism illustrated in figure 3-6, and refer to it as you study its operation.

As the finger of the right margin stop moves to the left, it contacts the margin stop release blade and moves it to the left. This action pivots the operating lever left and moves the linelock bellcrank to the right. The upper extension of the linelock U-bar is then pulled forward by the spring connected to the right end. This action pushes the linelock push bar to the rear and moves the lip on the rear of the linelock U-bar under the upper extension of the keylevers to lock the keyboard. This is the locking point.

When the margin release key is depressed, the margin release keylever swings down and raises the margin release toggle connecting



1. Escapement rocker
2. Type bar universal bar
3. Type bar
4. Type bar universal bar oscillator bracket
5. Type bar universal bar oscillator
6. Operating bail (roll)
7. Escapement trip pull wire
8. Loose dog
9. Escapement wheel (star wheel)

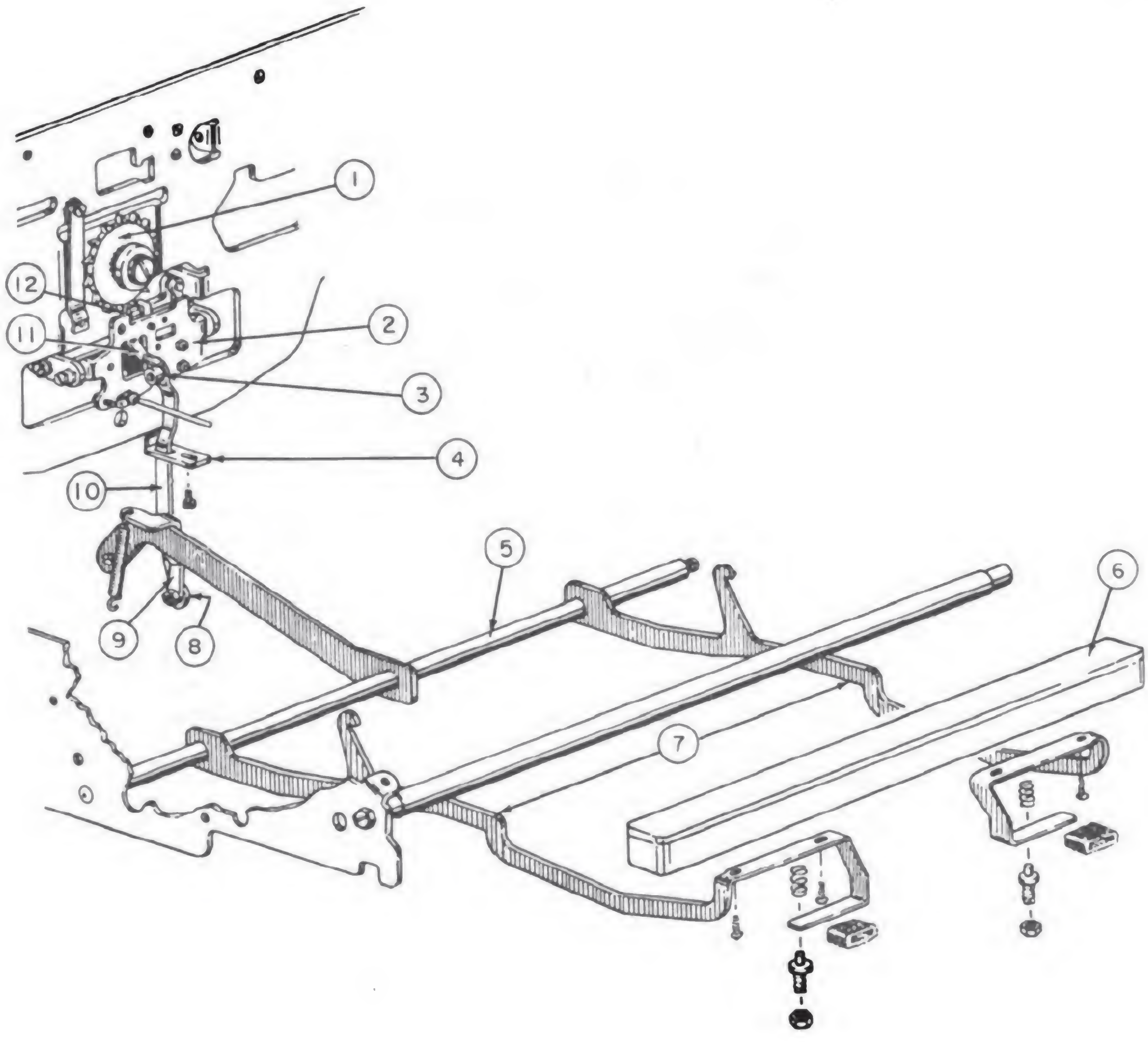
Figure 3-4.—Escapement mechanism.

61.39X

link. This action lifts the margin release push link, which pivots the front of the margin stop release blade down to allow the right margin stop to pass to the left.

BACKSPACE MECHANISM

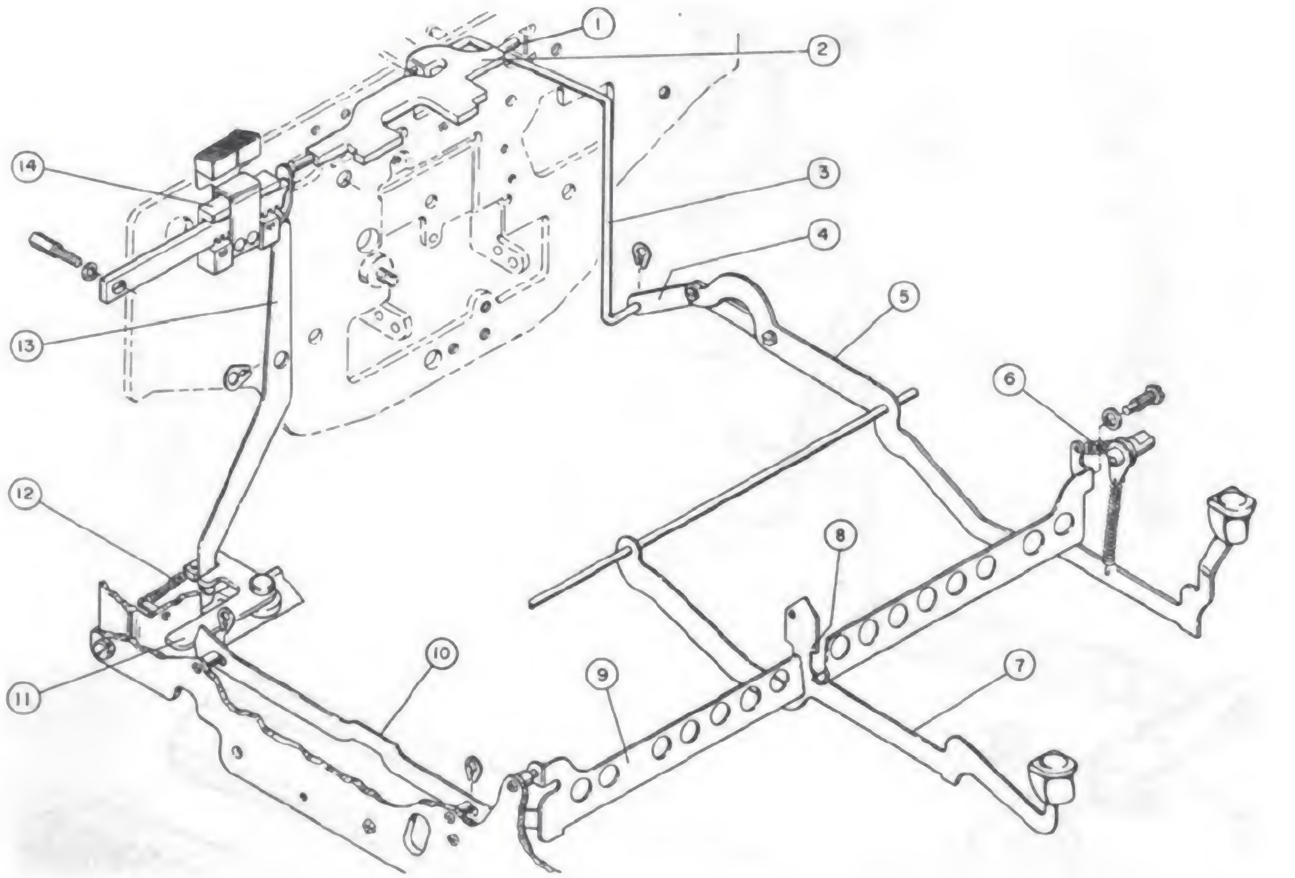
As the backspace key is depressed, the backspace keylever roll on the opposite end raises the front end of the backspace lever arm. See figure 3-7. When the front of the backspace lever arm moves up, the arm pivots and its back end pushes the end of the backspace pawl actuating lever on which it rests down. The other end of the backspace pawl actuating lever raises the backspace pawl, causing the tip on its top to engage a tooth of the star wheel and move it clockwise one full space.



1. Escapement wheel (star wheel)
2. Escapement rocker
3. Spacebar push link roll
4. Spacebar push link adjusting guide
5. Spacebar shaft and extension arm
6. Spacebar
7. Spacebar levers
8. Spacebar push link eccentric
9. U-shaped connecting link
10. Spacebar push link
11. Escapement rocker arm
12. Loose dog

91.3X

Figure 3-5.—Spacebar mechanism.



1. Contact point of right margin stop
2. Margin stop release blade
3. Margin push release link
4. Margin release toggle connecting arm
5. Margin release key lever
6. Linelock restoring spring
7. Key lever
8. Locking point
9. Linelock U-bar spring
10. Linelock push bar
11. Linelock bellcrank
12. Linelock restoring spring
13. Operating lever
14. Left margin stop

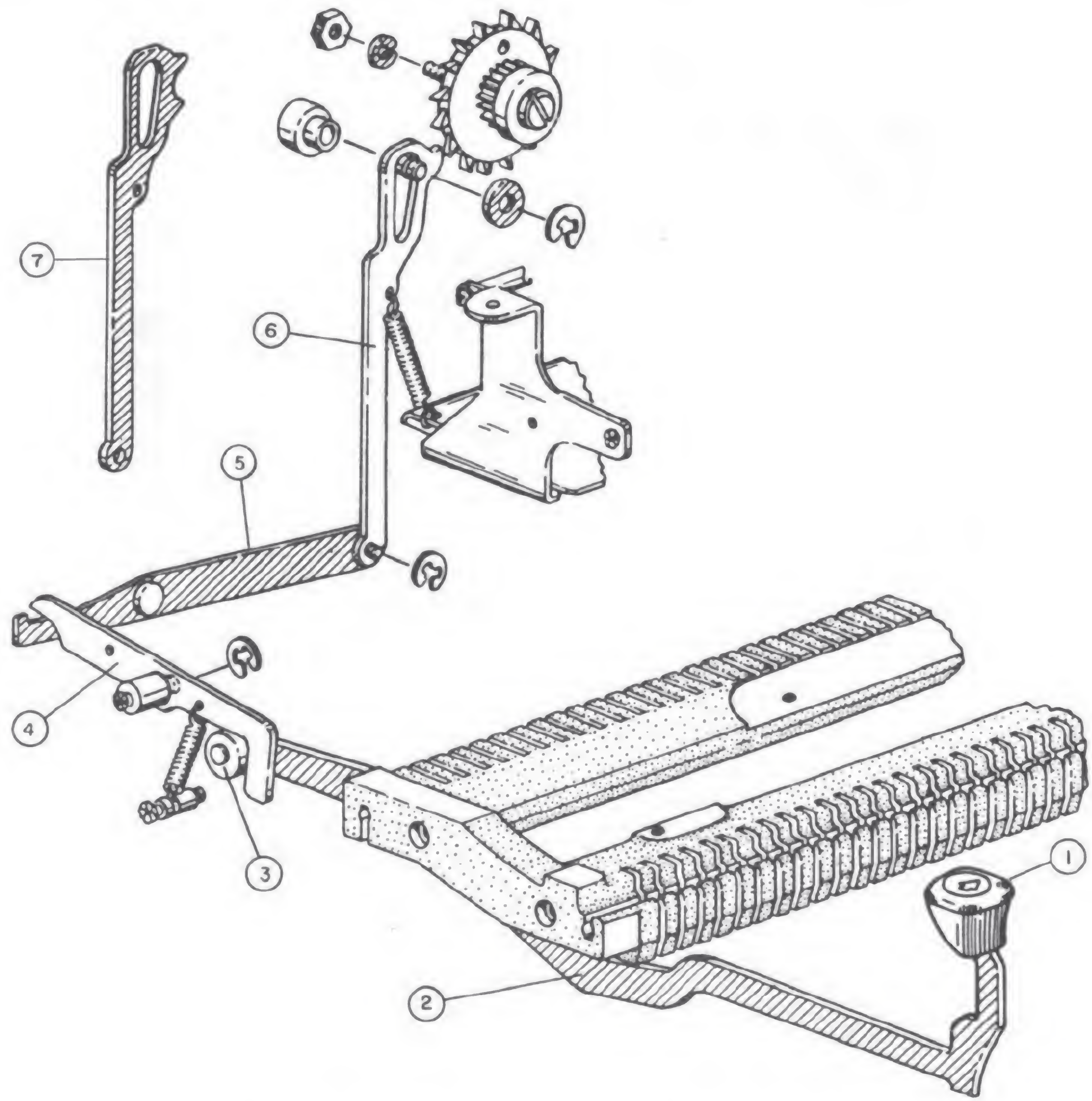
61.48X

Figure 3-6.—Linelock and margin release mechanism.

RIBBON SELECTION MECHANISM

When a typist moves the ribbon control lever (fig. 3-8) to a certain position, the ribbon control link moves the ribbon control shaft arm forward or backward, in accordance with the position of the control lever. As the ribbon control shaft arm moves, it carries the ribbon control shaft along, and the top of the ribbon control shaft control arm is also moved to the front, or to the rear. The top of the ribbon lifter push link is then positioned to the front or to the rear. (The ribbon lifter push link stud moves in a T-shaped slot of the ribbon actuator arm to one of four positions, and the position in the slot varies the amount of upward travel of the ribbon actuator arm.)

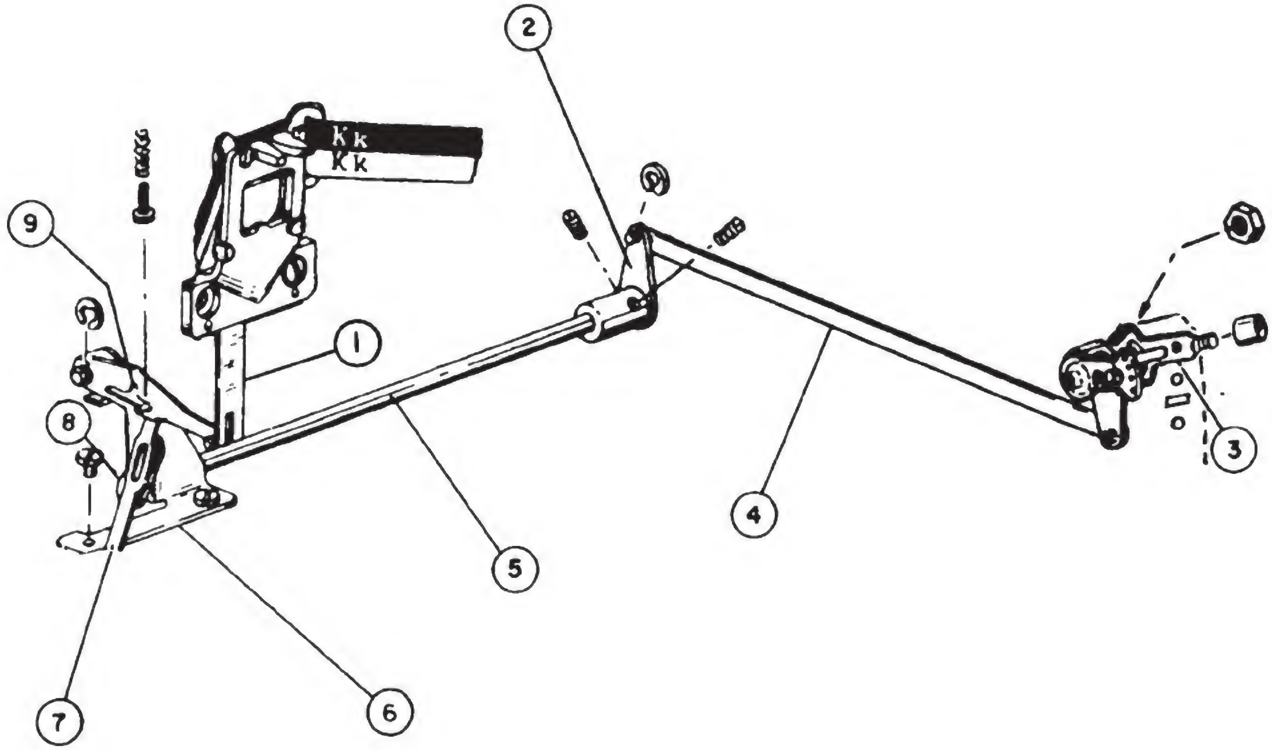
When the ribbon covers, the actuator arm is raised to one of three positions: red, black,



1. Backspace key
2. Backspace key lever
3. Backspace key lever roll
4. Backspace lever arm
5. Backspace pawl actuating lever
6. Pica pawl
7. Elite pawl

61.43X

Figure 3-7.—Backspace mechanism.



1. Ribbon guide
2. Ribbon shaft control arm
3. Ribbon control lever
4. Ribbon control link
5. Ribbon control shaft
6. Ribbon actuator arm bracket
7. Ribbon lifter push link
8. Ribbon control shaft control arm
9. Ribbon actuator arm (T-slot)

61.42X

Figure 3-8.—Ribbon selection mechanism.

center, and stencil. The ribbon guide is then raised and carries the ribbon to one of three positions.

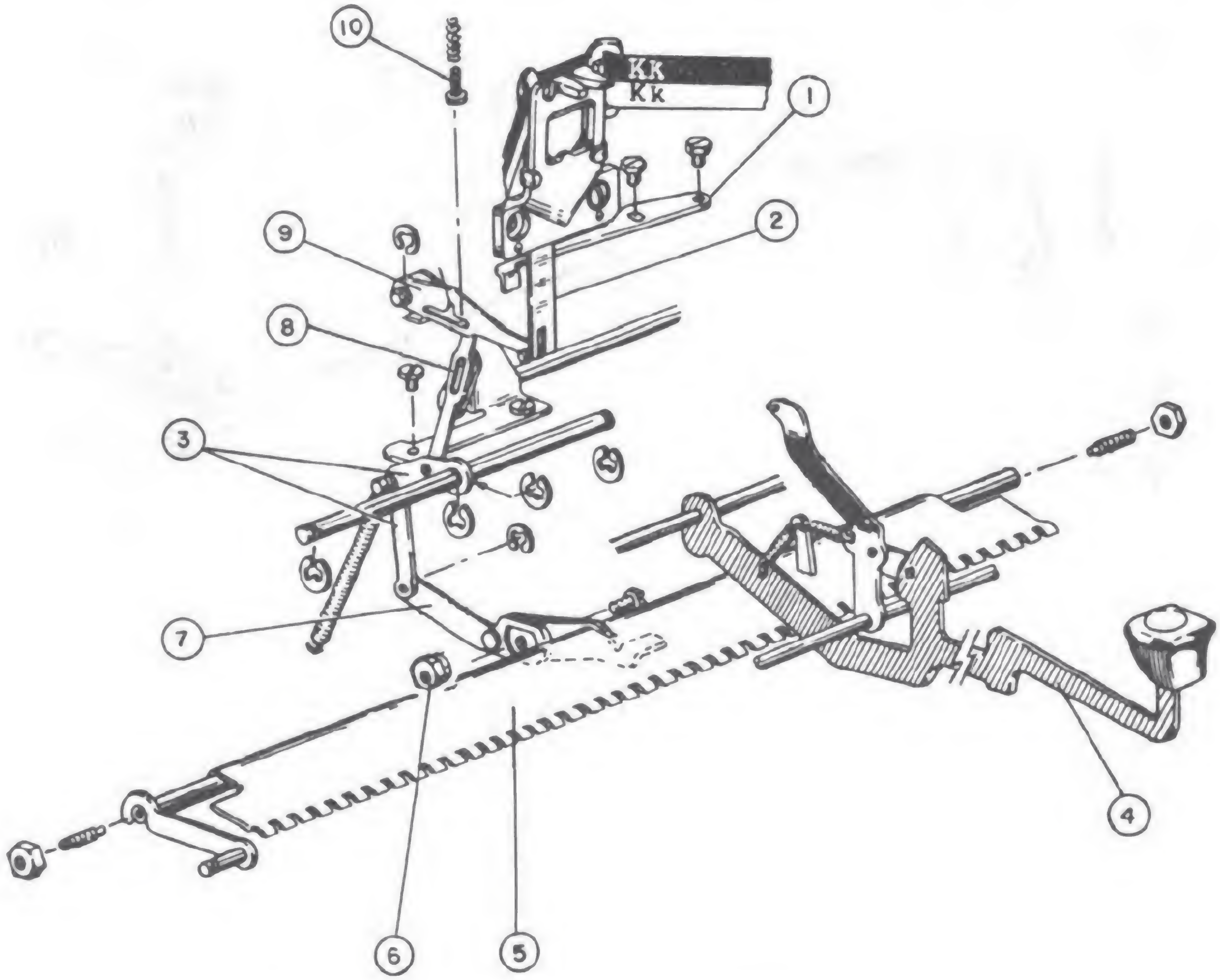
RIBBON COVER MECHANISM

When a keylever is depressed, it also depresses the front of the ribbon universal bar (fig. 3-9). This action raises the U-bar toggle link. (The toggle link is rigidly secured to the bottom of the ribbon U-bar. The ribbon U-bar eccentric adjusts the height of the front of the ribbon U-bar.)

As the ribbon U-bar toggle link rises, it lifts the ribbon lift bellcrank assembly, which pushes the ribbon lifter push link up. The front of the ribbon actuator arm is then raised, and the ribbon guide and ribbon are raised to cover the type. (The ribbon lifter push link stud contacts the black upstop screw and limits upward travel in the BLACK position. The ribbon actuator arm contacts the ribbon actuator arm stop and limits upward travel in the RED position.)

RIBBON FEED AND REVERSE MECHANISM

Refer to figure 3-10 as you study the operation of the ribbon feed and ribbon reverse mechanism. Note the pinion on the spring drum pinion shaft. This pinion meshes with a gear



1. Ribbon actuator arm stop
2. Ribbon guide
3. Ribbon lift bellcrank assembly
4. Keylever
5. Ribbon universal bar (U-bar)
6. Ribbon U-bar eccentric
7. Ribbon universal bar toggle link
8. Ribbon lifter push link
9. Ribbon actuator arm
10. Black upstop screw

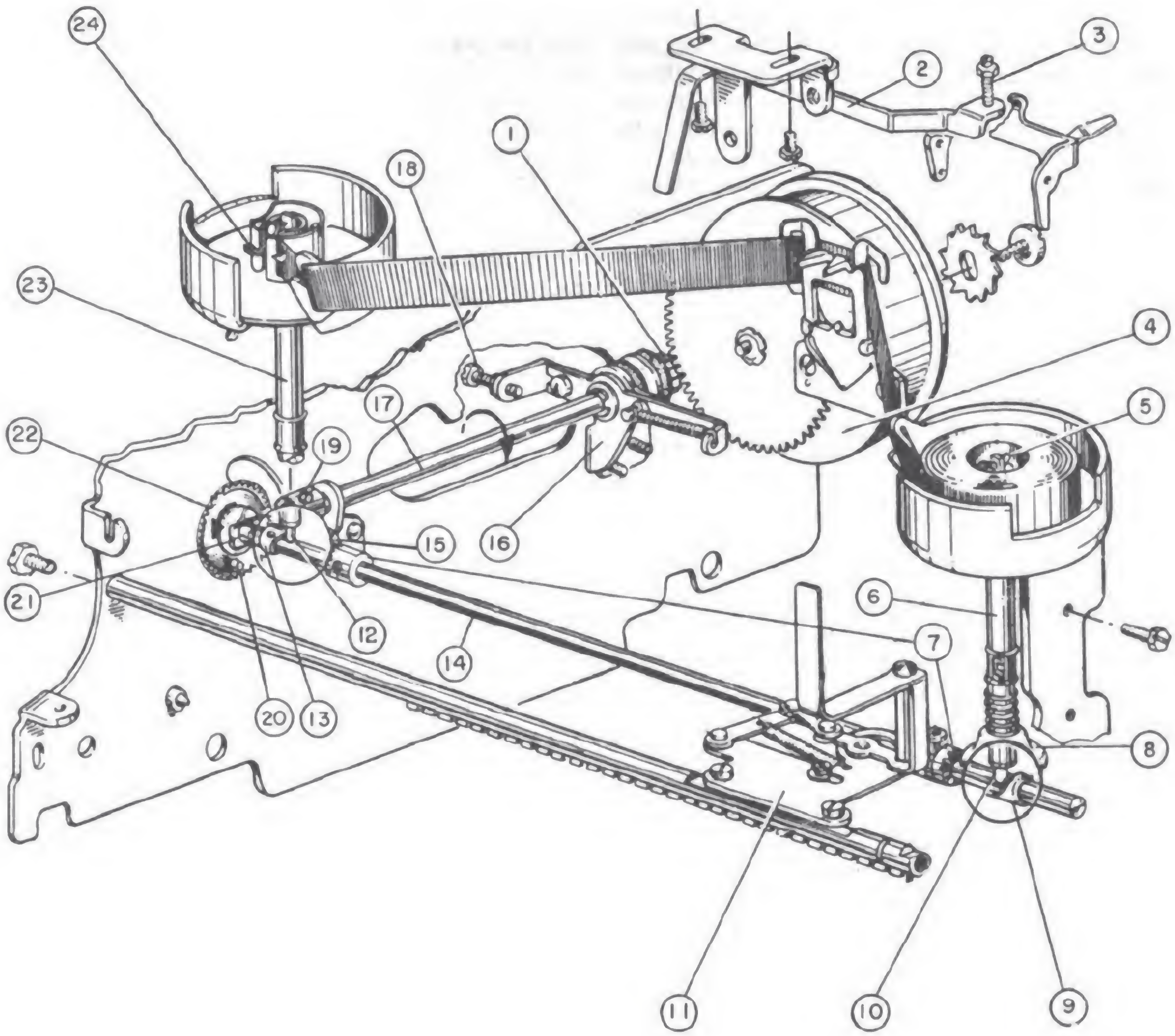
61.42X

Figure 3-9.—Ribbon cover mechanism.

connected to the spring drum. Some typewriters use a different system for operating the ribbon—movement of carriage, with appropriate chain and gear attached, pawl feed, and so forth.

As the carriage moves from right to left, the spring drum gear (meshed with the spring drum pinion on the spring drum pinion shaft) turns the spring drum pinion in the direction indicated by the arrow (fig. 3-10). The ribbon drive gear pinion meshes with the ribbon drive gear and drives the top of the ribbon drive gear forward. The ribbon drive gear stud engaged with the ribbon drive shaft arm turns the ribbon drive shaft top forward. The right ribbon driving gear is meshed with the ribbon spool shaft pinion and turns the right ribbon spool shaft counterclockwise, winding the ribbon onto the right spool.

When the ribbon is all wound on the right spool and the left spool is empty, the left reverse trigger is released and the left reverse plunger drops down into the path of the left



1. Ball clutch pinion
2. Pinion release bellcrank
3. Ribbon throwout screw
4. Spring drum
5. Reverse trigger (left & right)
6. Ribbon spool shaft (left & right)
7. Ribbon driving gear (left & right)
8. Ribbon spool shaft pinion
9. Ribbon reverse cam (left & right)
10. Ribbon reverse plunger (left & right)
11. Ribbon reverse detent plate
12. Reverse plunger (left and right)
13. Ribbon reverse cam (left & right)
14. Ribbon drive shaft
15. Ribbon spool shift pinion (left & right)
16. Spring drum pinion support bracket
17. Spring drum pinion shaft
18. Ball clutch pinion adjusting screw
19. Ribbon drive gear pinion
20. Ribbon drive gear stud.
21. Ribbon drive shaft arm
22. Ribbon drive gear
23. Ribbon spool shaft (left & right)
24. Reverse trigger (left & right)

61.41X

Figure 3-10.—Ribbon feed and reverse mechanism.

ribbon reverse cam, which forces the ribbon drive shaft to the left. The toggle on the ribbon reverse detent plate breaks (Note spring and toggle in the illustration.) to lock the ribbon drive shaft to the left. The ribbon then starts to reverse (left gears meshed) and to feed onto the left spool. As the ribbon starts to wind onto the spool, it presses the reverse trigger down and raises the left reverse plunger up, out of the way of the left ribbon reverse cam.

An important feature of this mechanism is the ball clutch (connected to the spring drum pinion) which allows the carriage to return without rotating the spring drum pinion shaft. In other words, the ribbon does not move when the carriage is moved left to right. When the right end of the pinion release bellcrank is depressed, the left end disengages the spring drum pinion from the spring drum (tab or carriage release action).

TABULATOR MECHANISM

When the tab bar is depressed, the tab connecting link moves to the rear and the tab bellcrank adjusting screw moves up with the rear of the tabbell crank. Study figure 3-11. The tab bellcrank adjusting screw contacts the tab stop blade and raises it up. The lip on the front of the tab stop blade then raises the front of the friction bail. The friction bail pivots on its fulcrum, and the lower extension of the friction bail pushes the lower extension of the escapement loose dog release bail forward. The friction bail toggle, in turn, breaks to allow the friction screw arm to move forward to slow the carriage down (friction type brake). The escapement loose dog release lip then depresses the loose dog and allows the star wheel to rotate. The ribbon throw-out screw goes down with the rear of the escapement loose dog release bail. The escapement loose dog restores before the tab blade drops clear of the SET tab stop, which prevents the carriage from traveling beyond the desired position.

KEY TENSION MECHANISM

The mechanism which controls key tension is illustrated in figure 3-12.

Key tension (key touch) is regulated by the amount of spring tension applied to the type bar bell cranks. Refer to part A of figure 3-12, which shows the key tension regulator lever in the UP position and the key tension slide to the front of the machine. Note the slanting position of the slots in the key tension slide. When the slide is pushed to the front of the machine, it moves a little to the left. While the slide is in the front position, the keylever spring is allowed full play and the LIGHTEST key tension is obtained.

If the key tension regulator lever is in the DOWN position, as illustrated in part B of figure 3-12, the key tension slide is in the BACK position and the key lever spring and bellcrank are inoperative; but the bellcrank spring can operate to increase key tension to its greatest amount.

DISASSEMBLY

You will normally disassemble a typewriter to the extent necessary to comply with the requirement of the work request. The first thing to do when you get a typewriter in the shop is to CHECK IT OUT to locate troubles which adversely affect its operation. The next step is disassembly to the extent necessary to locate trouble(s), or complete disassembly if the work request states OVERHAUL AND REPAIR. All data obtained during partial or complete disassembly should be recorded for entrance on the casualty analysis report.

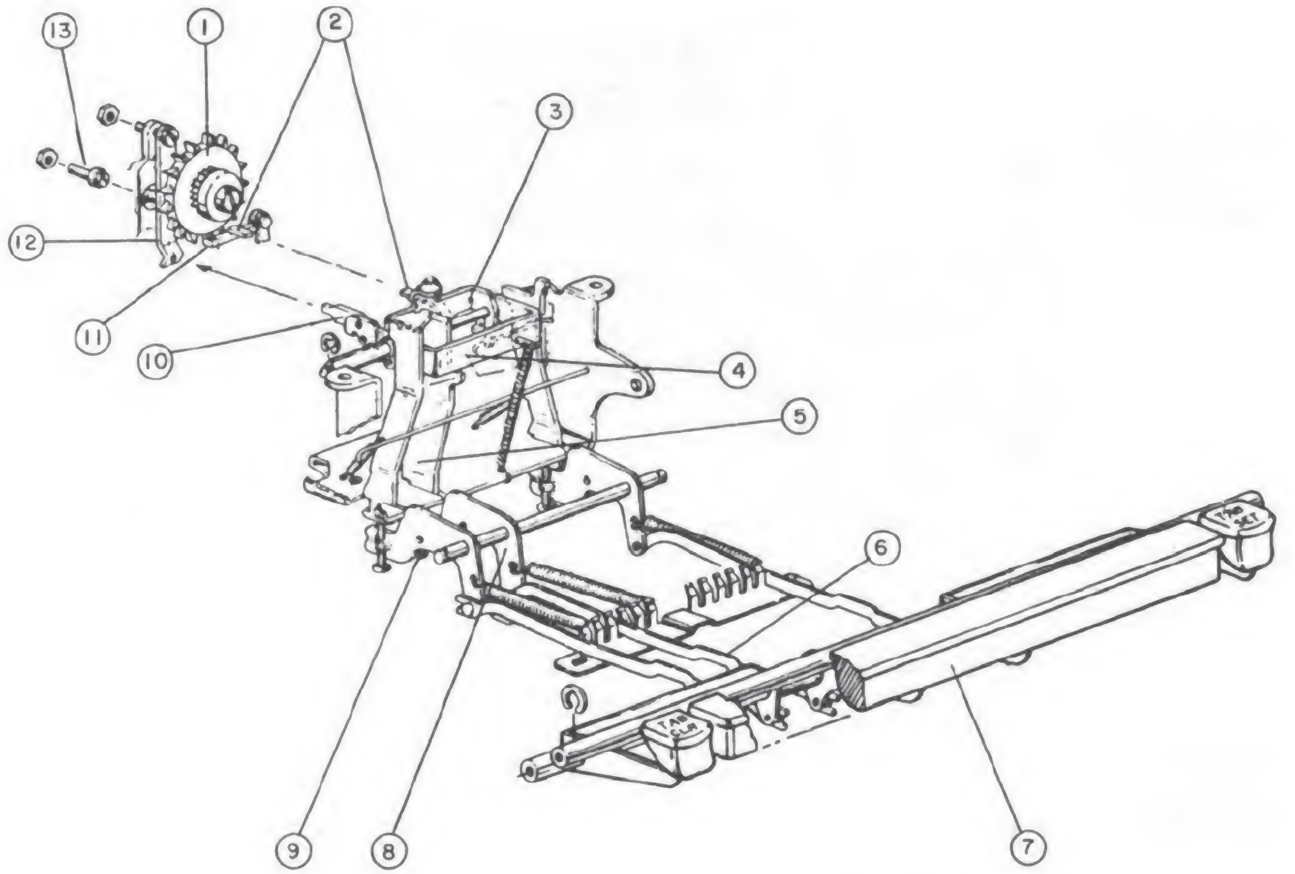
The procedure for disassembling a Remington standard typewriter is given next in sequential order. The part to be removed is listed first, followed by a brief description of the steps to follow in removing it.

1. Top cover.—With the machine facing you, pull straight up on the cover.

2. Ribbon winding disk, ribbon, and ring.—Disconnect the ribbon from the ribbon guide and wind all of it on the spool containing the ribbon ring. Then remove the winding disk from the unwound spool and disconnect the end of the ribbon attached to it. Wind all of the ribbon to the full spool; then remove the winding disk, ribbon, and spool.

3. Rear panel.—Remove two mounting screws, slightly raise the rear of the panel, and slide the panel rearward.

4. Side panels.—Remove front, rear, and top mounting screws and raise the rear of the panel to remove it from the base mounting stud.



1. Star wheel
2. Escapement loose dog release lip
3. Escapement loose dog release bail
4. Friction bail
5. Tabulator stop blade
6. Tab connecting link
7. Tabulator bar (TAB BAR)
8. Tab bellcrank
9. Tab bellcrank adjusting screw
10. Friction bail toggle
11. Loose dog
12. Friction screw arm
13. Tabulator friction spring adjusting screw

61.44X

Figure 3-11.—Tabulator mechanism.

Then slide the panel from the front stud and lower it enough to free it from the ribbon selector or touch control lever.

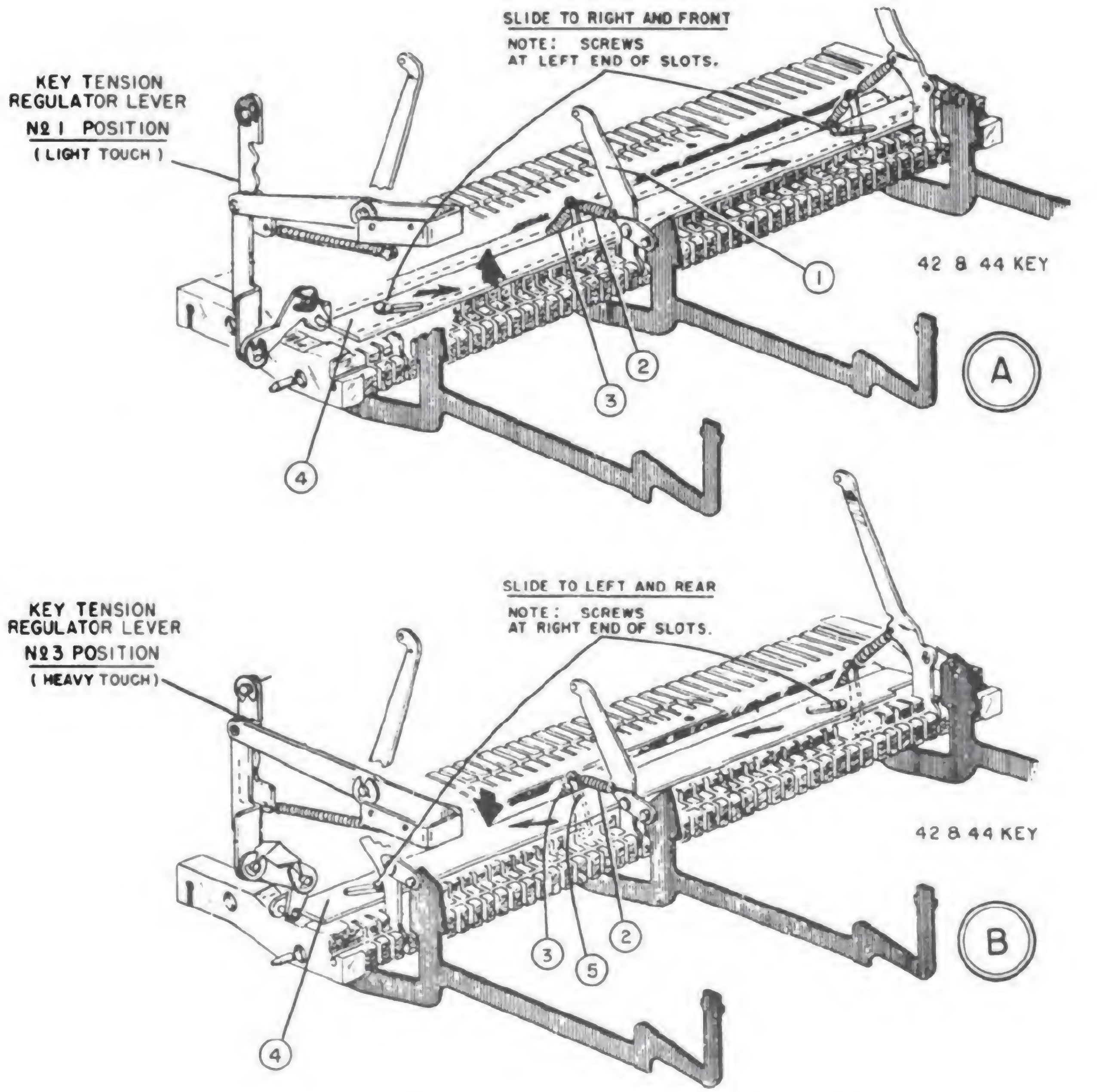
5. Front panel.—Release the mounting nuts at the rear of the front panel about 1/4 turn. Then loosen the screws which hold the upper front end of the side panels and remove the front panel.

6. Base.—Remove the mounting screws. (Do not lose shims, if any, between the base and side frames.) Base may be left on machine during cleaning; remove only when necessary.

7. Erasure shield.—Loosen the set screw in the right pivot stud and remove the square detent stud. Slide the erasure shield to the right to disengage it from the left pivot.

8. Paper table.—Remove the mounting nuts beneath the paper table and pull the paper bail and detent release lever to the front of the machine. Remove the paper table. CAUTION: Do not lose spacers between the top of the bracket and the paper table.

9. Carriage end covers.—Raise right and left carriage end hinges. Release platen locks and remove the platen. Remove next the carriage end hinge pivot screws (2) and remove the



1. Bellcrank
2. Bellcrank spring
3. Keylever spring
4. Key tension slide
5. Spring arm support

91.4X

Figure 3-12.—Key tension mechanism.

end hinges. Then remove the screws (4) on the outside of the carriage end covers and remove the covers.

10. Rear carriage margin stop back panel.—Remove bevel head screw at each end of the panel and lift the panel out.

11. Carriage assembly.—Disconnect the draw band from the right end of the carriage and hook it over the anchor post on the back frame. Remove the upper carriage support bail roll, and the binding screws and the eccentric screw from each end of the carriage bed rail assembly. Pull the carriage forward and rock the top rearward. Remove the aligning scale and bracket and lift the carriage from the machine. Depress the shift when you pull the carriage forward.

12. Back frame.—Remove the two keepers from the margin release pull link and then remove the link. Remove next the top screws and loosen the bottom screws on the left and right side frames. Pull the top of the back frame rearward and down, and disconnect the spacebar tension spring from the back of the frame. Remove the nut and the eccentric screw from the bottom of the spacebar push link, and remove the screw from the adjusting guide and work spacebar push link from the machine. Then remove the bottom screws from the right and left side frames and remove the back frame.

13. Escapement frame.—To remove the escapement frame from the back frame, do the following:

a. Loosen the escapement link lock arm binding screw and disengage the escapement trip pull wire from the escapement rocker.

b. Remove the spring clip and spacer from the top of the backspace pawl. Disconnect the spring, remove the spring clip from the lower end of the pawl, and remove the backspace pawl.

c. Remove the spring clip from the linelock operating lever stud and remove the lever.

d. Remove the hexagonal screws (3) with lock washers and then remove the escapement frame.

14. Escapement rocker assembly.—Position the escapement with the escape wheel facing you. Then loosen the lock nuts, pivot screws, and remove the escapement rocker from the frame.

15. Escape wheel.—Remove the lock nut and washer from the bearing screw and remove the escape wheel. Then disassemble the loose dog silencer.

16. Disassembly of escapement rocker assembly. Proceed as follows:

a. Disconnect the loose dog spring from its guide.

b. Remove the loose dog fulcrum screw, the space washer, lock nut, and washer.

c. Remove the loose dog carrying arm limit cushion screw, lock nut, and washer.

d. Remove the loose dog assembly from the rocker.

e. Remove the loose dog guide screw and then the guide.

17. Disassembly of carriage.—Disassemble the carriage in the following manner:

a. Remove the linespace lever.

b. Pull the platen release lock forward and lift the platen out.

c. Remove the paper trough and feed rolls (front and rear).

d. Remove the tab stop screws and rack.

e. Remove the hexagonal binding screws from each end of the carriage support rail.

f. Remove the carriage release blade (nuts on carriage release lever) and slide the blade assembly to the left and out.

g. Remove the margin rack binding screws (2) and then the rack.

h. Remove the tabulator stop set assembly and then the carriage bed from the rail.

18. Margin release shaft.—Remove the spring clip from the rear extension of the margin release key and then the link from the stud. (Remove spring from ribbon lift bellcrank assembly.) Next, remove the spring clip from the right end of the shaft and slide the shaft to the left until the right end is clear of the frame. Pull down and out to remove.

19. Ribbon control lever and link.—First, take the spring clip from the rear end of the ribbon control link. Then remove the nut, spacer, ribbon control lever, and the spring from the stud on the right side of the frame.

20. Ribbon control shaft and actuating lever assembly.—Loosen the set screws (2) in the ribbon control shaft control arm and remove the arm. Next, take out the two screws from the ribbon actuator arm bracket and disengage the ribbon lifter push link stud from the slot in the ribbon actuating lever. Then disengage the stud on the ribbon control shaft arm from the slot of the ribbon lifter push link. Remove the ribbon guide from the type guide and lift the assembly from the machine.

21. Ribbon spool shaft assemblies.—Disconnect the type bar restoring bail spring from its

anchor post. Then remove the hexagonal screws (2) from each bracket and lift the assemblies from the machine.

22. Tabulator lever shaft.—Remove the hexagonal screw from each end of the shaft and then take the shaft from the machine.

23. Ribbon drive shaft.—To remove the ribbon drive shaft, proceed as follows:

a. Slide the shaft to the right until the left end clears the drive gear.

b. Lift the left end of the shaft up into the opening of the left side frame.

c. Pull the shaft left enough to clear the right frame.

d. Pull the right end of the shaft forward and work the shaft from the machine.

24. Linelock universal bar (U-bar).—Loosen the head pivot screw from the right side frame to release the U-bar and then remove it from the machine.

25. Type bars and connecting links.—Remove the type bar fulcrum wire retaining screws (2) from the top corners of the segment casting. Then use a spare fulcrum wire to force the segment fulcrum wire out SLOWLY, and remove each type bar and link individually, starting with the first type bar on the left of the segment. Place each type bar connecting link in a wooden block (provided with the machine) and in the order removed. String type bars on a length of wire in the order removed.

26. Type bar cushion assembly.—Remove the screws (2) and then the cushion.

27. Type bar U-bar assembly.—Disconnect the oscillator spring from the anchor post. Then remove the screws (2) from the U-bar oscillator bracket and lift the assembly from the machine.

28. Segment.—Disconnect the segment balance springs and remove the segment pivot screws. Then lift the segment from the machine. CAUTION: Do not loosen the segment ball race bearings.

29. Segment shift rocker.—Partially unscrew the right segment rocker pivot screw and work the rocker from the machine.

30. Disassembly of platen and variable mechanism.—Remove the left platen knob, spacer and spring, and the variable cover plate screws. Put a finger over the left end of the platen and pull up the cover plate. Slide the variable linespace lever dogs onto the platen shaft. Then remove the finger from the platen end and the variable linespace clutch ball and spring from the inside shaft. Finally, take out the variable linespace ratchet and the variable linespace dogs.

CLEANING PROCEDURE

The recommended procedure for cleaning the Remington standard typewriter follows. Although this cleaning method is specifically recommended for Remington typewriters, it is also good for cleaning any make of standard typewriter.

1. Remove the panels, ribbon, platen, and rubber feed and scale rolls. (Rubber is damaged by the cleaning solution.)

2. Prepare a cleaning solution as recommended by the manufacturer of the basic cleaning agent specified by Remington Rand for cleaning their typewriters. Generally, 4 parts of kerosene are added to 1 part of the cleaning agent. NOTE: The cleaning solution given in <u>Instrumentman 3 & 2</u>, NavPers 10193-B, as recommended by the Navy, is good for cleaning the mechanical parts of all makes and models of typewriters. Follow instructions carefully.

3. Put the cleaning solution in the tank used for cleaning typewriters, or a typewriter washing machine. This machine consists of an open tank with a specially constructed rack for holding the typewriter while an electric motor operates the machinery which raises and lowers it (up and down motion) in the cleaning solution. The speed at which the machine is raised up and down is sufficient to agitate the solution to the extent necessary to force it into all recesses and crevices of the machine in order that it may dissolve dirt and grease.

4. Set the typewriter on the frame of the washing machine and run the machine 10 to 15 minutes.

5. Remove the machine from the washer and wash it thoroughly under a hot water spigot in a tank. Run the water long enough to remove all traces of the cleaning solution.

6. Put the typewriter on a metal drain board and dry the machine thoroughly with an air hose.

7. Oil the typewriter with No. 3 oil.

8. Put the machine in an electric oven (if available) and bake it for 15 minutes. The heat makes the oil thin and it then runs into crevices of the machine.

9. Remove the typewriter from the oven and put it on a metal drain board as long as necessary to drain off excess oil.

10. Clean the platen and all rubber parts with a clean cloth moistened with alcohol or lacquer thinner.

11. Clean panels and other uncleaned parts with a clean cloth dampened with alcohol, or a recommended commercial solvent or cleaning agent.

As you learned in Instrumentman 3 & 2, NavPers 10193-B, if you do not have a special washing machine for typewriters, put the nozzle of an air hose to the bottom of the cleaning tank and keep air passing through it while the typewriter is in the tank. It is best to have the air hose connected to a coiled copper tube, perforated at intervals, placed in the bottom of the cleaning tank. The purpose of the air, of course, is to agitate the solution to the extent necessary to force it into crevices in the typewriter.

INSPECTING AND REPAIRING

Inspecting and repairing as used in this section are limited to the work you do on a typewriter after you clean it. At this time, you should inspect all parts of the machine for defects or damage you may have overlooked during disassembly.

Bent links and levers in a typewriter may be straightened. Broken parts, of course, must be replaced. The rule to follow with respect to defects in parts is this: REPLACE DEFECTIVE PARTS WHEN YOUR JUDGMENT TELLS YOU THEY WILL PROBABLY ADVERSELY AFFECT THE OPERATION OF THE TYPEWRITER.

Review the chapters on office machines and repair tools and processes in Instrumentman 3 & 2, NavPers 10193-B, for that information will always be helpful to you in repairing typewriters.

As you will learn through experience in typewriter shops, the greatest percentage of typewriter repair consists of the reshaping or the replacing of parts. If you understand the function of parts and mechanisms in a typewriter, you will soon learn through actual experience in instrument shops how to make all repairs on different makes and models. Precision in the work of a mechanic is the result of knowledge plus excellent experience.

REASSEMBLY

After you complete the repair work on a disassembled typewriter, your next task is to reassemble it. The step-by-step procedure for doing this is given in the accompanying chart, for a Remington standard typewriter.

Name of Part	Assembly Procedure	Key Points
Variable Mechanism	a. Replace variable line spacer (VLS) ball spring. b. Replace VLS dogs and spring assembly. c. Replace VLS clutch ball. d. Replace VLS ratchet. e. Replace VLS ratchet plate. f. Replace platen knob. g. Depress VLS plunger and position dogs. h. Position ratchet in place. i. Position VLS cover plate and replace screws. j. Remove platen knob, left. k. Tighten VLS cover screws. l. Replace platen spacer spring, spacer, and knob.	Keep big end of spring up. So position the dogs that the longest side is up. Do NOT tighten screws. Large end of spacer must be outboard.
Segment shift rocker	Place rocker in position and secure it with the pivot screw and lock nut.	Rocker should work freely, but should have no end play.

Name of Part	Assembly Procedure	Key Points
Segment	a. Adjust V blocks for .025" between the rear of the V block and the side plate support bracket. b. Place segment in position. c. Replace segment race ball bearings. d. Replace segment pivot screws and nuts. e. Adjust right V block as necessary in order to eliminate side shake of segment.	Loosen the binding screw before you make the adjustments. Put screws in from LEFT to RIGHT. Do NOT use left-hand V block.
Segment shift toggle assembly	a. Place toggle in position and connect to segment rocker. b. Replace the rear toggle eccentric and binding screw. c. Replace forward toggle eccentric, binding screw, and spacer. d. Connect toggle to the right shift keylever extension and replace the binding screw and segment shift toggle yield link eccentric. e. Connect the shift toggle spring to the anchor post.	For initial adjustments, position both eccentrics with the HIGH point down.
Type bar and connecting links.	a. Start on the right and place the connecting link in the hole of the type bar. b. Place connecting link in hole of bellcrank. c. Place type bar in segment. d. Insert fulcrum wire through hole of No. 44 type bar. e. Repeat the above sequence to replace the remaining type bars. f. Secure the fulcrum wire by replacing the lock screws (2).	On machines with 44 keys, hooks of connecting links 1 through 22 face outboard to the left in the type bars. Hooks of connecting links 23 through 44 face outboard to the right of the type bars. Connecting links 22 and 23 have flat surfaces. Connect the flat surface end to the type bar. Be sure fulcrum wire is clear of the lock screw hole before you replace the screw.
Type bar U-bar assembly	Put the assembly in position and replace the U-bar oscillator bracket screws. Connect the U-bar oscillator spring to the anchor post.	U-bar must work freely. There must be NO binds. Do NOT overlook U-bar stud compression spring.

Name of Part	Assembly Procedure	Key Points
Linelock U-bar	Replace the pivot screw.	
Ribbon drive shaft	a. First, check to determine whether the ribbon reverse cams are facing each other, and one high point is up and the other down. b. Position the left end of the shaft in the crescent opening of the left side frame. c. Work the right end of the shaft into the hole in the right frame. d. Work the left end of the shaft into position.	Position the stud in the drive shaft arm.
Tab lever shaft assembly	Put in position and secure with two hexagonal screws.	On machines with 44 keys: a. Tab CLEAR is between No. 15 and No. 16 bellcranks. b. Tab KEY connecting link is between No. 18 and No. 19 bellcranks. c. Tab SET connecting link is between No. 29 and No. 30 bellcranks.
Tab upstop shaft assembly	a. Place in position, with the ribbon reverse bail engaged in the slot of the ribbon reverse collar, and the ribbon reverse detent stud in the slot of the right ribbon drive gear. b. Secure the shaft with the two hexagonal screws. c. Connect the linelock U-bar spring to the anchor. d. Connect the margin release lever spring to the anchor.	The ribbon detent should NOT bottom in the slot.
Type bar cushion	Place in position and secure with screws (2).	
Ribbon spool shaft assembly	a. Place in position and secure with hexagonal screws (2) in each bracket. b. Connect the type bar restoring bail spring to the anchor (left side).	

Name of Part	Assembly Procedure	Key Points
Ribbon control shaft assembly	a. Insert the shaft into the hole in the ribbon. b. Position the shaft in the hole of the right frame. c. Position the stud of the ribbon control shaft control arm in the slot of the ribbon push link. d. Position the stud of the ribbon lift push link in the slot of the ribbon actuator arm. e. Position the ribbon guide in the type guide. f. Secure the ribbon actuator arm bracket with screws. g. Replace the ribbon control shaft arm.	This shaft should have minimum end play. Ribbon push link stud should be centered in the slot of the ribbon actuator arm when the type bar is against the segment anvil.
Ribbon control lever and link	a. Replace the spring (flat detent). b. Replace the spacer. c. Replace the control lever and link assembly. d. Secure with the lock nut. e. Fasten the ribbon control shaft arm with the spring clip.	
Ribbon upstop plate	Position the plate with the stop down and secure it with four screws.	The ribbon actuator arm should almost touch the ribbon actuator arm stop when a type bar is against the anvil and the ribbon control lever is in the red position. More throw can be obtained by adjusting the ribbon U-bar eccentric. Position the high point of the ribbon U-bar eccentric to the rear.
		The ribbon lifter push link stud should contact the black upstop screw when the ribbon control lever is in the black position and a type bar is held against the platen Adjust by turning the black upstop screw. Adjust the ribbon actuator arm by positioning the ribbon actuator arm stop.

Name of Part	Assembly Procedure	Key Points
Margin release shaft assembly	a. Replace through the bottom. b. Place left end of the shaft in position. c. Place the right end of the shaft in position and secure with the spring clip. d. Connect the upper right extension to the margin release key and secure it with the spring clip. e. Connect the ribbon lift bellcrank spring to the spring anchor on the margin release shaft.	
Carriage	a. Replace the carriage bed rail. First, slide the carriage truck assembly onto the carriage roll rail; then slide the carriage bed rails over the trucks and the carriage roll rails from the right side.	When the carriage rail left end is centered with the carriage, center the truck pinion with the small hole in the left end of the bed rail.
	b. Secure the tab stop set assembly to the bottom of the carriage with binding screws (2).	
	c. Replace the carriage release blade between the carriage ends.	Short end of the shaft and the tension spring go on the right end. The carriage release levers (right and left) are secured on the shaft with binding nuts (2).
	d. Replace the tab rack between carriage ends and secure it with two binding screws.	Open end of the rack should be forward.
	e. Replace the margin stop rack on the rear of the carriage and secure it with binding screws (2).	The carriage release blade spring should be forward on the right end of the tab rack.
	f. Replace the carriage support rail and feed rack assembly, teeth downward, and secure it with binding screws (4).	Be sure to install the draw band spring anchor on the right end when you insert the two binding screws there.
	g. Replace the front and rear feed rolls.	Feed rack goes on the rear. Spring anchor goes to the rear of the support rail.
	h. Replace the paper trough.	

Name of Part	Assembly Procedure	Key Points
Carriage (Continued)	i. Replace the platen. j. Replace the linespace lever. k. Position the rear carriage bed rail as necessary to remove the play from the carriage rail and carriage bed.	Loosen screws (6) and position the rail.
Escapement rocker	a. Replace the loose dog guide. b. Replace the loose dog assembly and secure it by replacing the fulcrum screw, the spacer, and the lock nut. c. Replace the loose dog limit cushion spring, the screw, and the nut. d. Connect the spring. e. Replace the tab friction arm compression spring.	There must be NO binds. Spacer goes between the loose dog and the escapement rocker. Check for .043" to .045" clearance between the loose dog and the rigid dog. Check with the loose dog limit cushion spring screw out, so that the loose and rigid dogs are opposite each other. To adjust, form the rigid dog.
Loose dog silencer and escape wheel	a. Replace the carriage support rail roller and lower the escape wheel onto the bearing screw. b. Place the wheel in such position that the loose dog silencer limit screw is in the slot of the silencer. c. Secure the escape wheel to the escapement frame with a lock washer and nut. d. Adjust the loose dog silencer limit screw.	Pica escape wheel has 15 teeth on it and 15 teeth on its pinion. Elite escape wheel has 18 teeth and its pinion has 18 teeth. Enough tension should be put on the loose dog silencer to hold the loose dog clear of the escapement wheel, thus eliminating noise.
Rocker assembly and compression spring	Place the assembly in position and secure it with pivot screws and lock nuts.	With the escape wheel held limited by the loose dog, the face of the escape wheel tooth and the face of the loose dog should be flush, referred to as the 6 o'clock position. Adjust by positioning the right escapement rocker pivot screw and nut.

Name of Part	Assembly Procedure	Key Points
Rocker assembly and compression spring (Continued)		With an escape wheel tooth held directly behind the rigid dog, there should be .025" to .030" clearance between the rigid dog and the escape wheel. There will be .015" to .020" between the front edge of the loose dog and the front edge of a star wheel tooth. Adjust the lower escapement rocker limit screw to get proper dimensions.
Escapement frame	a. Put the paper gasket in position at the top of the back frame.	
	b. Place the escapement frame in position and secure it with screws and lock washers.	Make certain that the bail toggle fits in the hole in the bottom of the tab friction screw arm.
	c. Replace the linelock operating lever and secure it with the spring clip.	
	d. Replace the backspace pawl and secure it with spring clips (2) and then connect the spring.	Spacer on upper stud goes on forward part of the pawl.
	e. Replace the escapement trip pull wire in position and secure the lock arm.	
	f. Replace the spacebar push link and push link adjusting guide.	
Back frame	a. Put the frame in position, with the rear extension of the margin release shaft through the hole in the center of the bottom of the frame.	
	b. Replace the No. 3 screw in the back frame.	
	c. Replace the spacebar push link eccentric and secure the push link to the U-shaped connecting link with the screw and nut.	High point of the eccentric should be forward. The spacebar push link roll should contact the forward end of the escapement arm. Adjust by positioning the push link adjusting guide.
Carriage	a. Place the aligning scale and bracket in position behind the ribbon guide.	
	b. Work the carriage into position and secure it by	

Name of Part	Assembly Procedure	Key Points
Carriage (Continued)	(1) Depressing the shift and replacing the carriage aligning scale bracket screws.	
	(2) Replacing the binding screw and eccentric in each end of the carriage bed.	Remove the upper roller, washer, and clip. Have the eccentric high point inboard.
	(3) Replacing the upper carriage support rail roll and spacer and securing it with a spring clip.	The spacer goes forward.
	(4) Connecting the draw band to the anchor on the right end of the carriage.	
	c. Replace the ribbon and make final adjustments (explained later).	
Panels	Replace in reverse order to the disassembly procedure.	

TESTING AND ADJUSTING

After you complete the reassembly of a typewriter, give it a thorough check to determine how various parts and mechanisms function. Make necessary adjustments as you test the machine.

The adjustment procedure described in this chapter is for the Remington standard typewriter. Adjustments for other makes and models vary in accordance with differences in construction and operation, so it will be necessary that you check the manufacturers' technical manuals for these machines to learn how to make proper adjustments on them. Lack of space prohibits a discussion of the adjustment procedure of other typewriters in this chapter.

As you study the adjustment procedure for a particular part or mechanism of the Remington typewriter, refer to the applicable illustration.

ADJUSTMENT OF BACKSPACE MECHANISM

The backspace mechanism is simple in construction and requires little adjustment. Parts of the mechanism must have freedom of movement. When the mechanism does not operate properly, make the following checks:

1. Tension of the pawl spring (fig. 3-7). The pawl spring must have enough tension to hold the pawl clear of the star wheel teeth.
2. Freedom of movement and wear of the pawl. If wear of the pawl interferes with proper action, replace it.
3. Alignment of the backspace keylever roll with the backspace lever arm. If the alignment is incorrect, adjust as necessary.

ADJUSTMENT OF SPACEBAR MECHANISM

Before you adjust the spacebar mechanism, check the adjustment of the escapement rocker body lower adjusting screw, and also loosen the escapement rocker body upper adjusting screw. The spacebar shaft should have freedom of movement but NO end play between the pivot points (fig. 3-5). Remove end play by adjusting the screw at the right end of the shaft; then secure the screw with the lock nut.

The height of the spacebar should be 5/16" below the tops of the lowest row of alphabet keys. Make this adjustment by forming the spacebar upstops, and then check the linelock for proper locking of the spacebar.

The screw hole in the spacebar push link adjusting guide is elongated to allow adjustment of the spacebar push link to its proper position. For lighter space action, locate the push link roll near the front end of the arm. The spacebar push link roll must NOT touch the escapement rocker arm. Unhook the spring on the U-shaped connecting link and test the spacebar mechanism for freedom of movement. The spacebar push link must be free in its adjusting guide. When you make this test, hold forward the lower part of the escapement rocker body and check for binds. Escapement should take place just before the spacebar contacts the springs on the downstop screws. Hold the spacebar against these springs and adjust the upper rocker body stop screw enough to get .020" more movement in the escapement rocker body.

RIBBON MECHANISM ADJUSTMENTS

Refer to illustration 3-10 as you study the procedure for making adjustments to the ribbon mechanism.

Set the left margin stop at the end of the carriage and move the carriage to the right. Completely unwind the mainspring, and use the thumb to rotate the top of the mainspring to the right and to the left. While doing this, observe the ribbon shaft as it rotates and check for:

1. A DRAG OR BIND. If either exists, check the ribbon drive gear pinion for proper meshing with the ribbon drive gear. The pinion should mesh deeply with the drive gear but still have a slight amount of play. (Make this test also with opposite driving gears.)

2. CORRECT MESHING OF BALL CLUTCH PINION WITH THE SPRING DRUM GEAR. Adjust the pinion adjusting screw as necessary to have the pinion deeply meshed with the spring drum gear, but with a slight amount of end play.

With the carriage still at the right, depress the tabulator bar slowly and observe the movement of the ribbon throw-out screw and the pinion release bellcrank before the ball clutch pinion starts to move outward. There must be a slight amount of movement here. Depress the tab bar, and then the right and left carriage release levers to determine whether each disengages the clutch pinion from the spring drum gear. If the clutch pinion does not fully disengage, adjust the ribbon throw-out screw downward until disengagement is complete.

Ribbon Reverse Mechanism

Before you adjust the ribbon reverse mechanism, make certain that you have proper ribbon spool shaft clearance and tension. The ribbon reverse detent stud should not mesh tightly in the right ribbon driving gear. There should be .008" clearance between the ribbon spool shaft collar and the bottom of the ribbon spool shaft bracket. Adjust accordingly by positioning the ribbon spool shaft pinion. The ribbon reverse plunger should have freedom of action. If there is a bind in this plunger, reshape it as necessary to remove the bind.

The ribbon spool shaft spring should have just enough tension to support a full ribbon spool and ribbon winding disc. Adjust as required by positioning the ribbon spool shaft collar.

Wind all the ribbon onto the left spool and then adjust the ribbon reverse and drive shaft in the following manner:

1. Loosen the right ribbon driving gear screw.
2. Position the ribbon reverse detent to the rear.
3. Loosen the ribbon reverse detent plate screws.
4. Position the ribbon reverse detent plate to the extent necessary to have proper meshing of the right ribbon driving gear with the right ribbon spool shaft pinion.
5. Tighten the ribbon reverse detent plate screws.
6. With the point of the right ribbon reverse plunger down, position the ribbon drive shaft as necessary to have the high point of the ribbon reverse cam up and a slight clearance between the cam and the plunger.
7. Tighten the right ribbon driving gear screw.
8. Position the ribbon detent toggle forward and position the left ribbon driving gear as required to have it mesh properly with the left ribbon spool shaft pinion.

The ribbon U-bar should have minimum end play. Make proper adjustments with the pivot screws. Adjust the ribbon U-bar fingers as necessary to have the keylevers contact the ribbon U-bar when the type bar is raised one half inch.

Ribbon Cover Mechanism

The following discussion of adjustments of the ribbon cover mechanism are for a typewriter equipped with a 1/2" black and red ribbon. The black part must be adjusted for ribbon cover. Proceed as follows to make correct adjustments:

1. So adjust the ribbon U-bar (pivot screws in ends) that its lips are in line with the keylever. This bar must be free but must have NO end play.
2. Position the large side of the U-bar eccentric to the front of the machine and temporarily lock the eccentric. (May have to relocate later for finer adjustment.) Review illustration 3-9.
3. Remove the retainer and disconnect the ribbon lift bellcrank assembly from the ribbon U-bar toggle link. With the shift key depressed, bring the underscore type bar against the anvil. The edge of the ribbon should now be 1/32" below the underscore. If this is not so, form the stop of the ribbon actuator arm to get the correct position of the edge of the ribbon.
4. Set the ribbon selection lever in the stencil position (white dot) and check the position of the stud in the ribbon actuator arm. It should be in the center of this arm; if it is not in this position, release the screws in the shaft and arm which control it enough to enable you to position the stud properly. Retighten screws. CAUTION: This initial adjustment must be exact.
5. Move the ribbon actuator arm stop to the rear and raise the upstop screw. Then put the ribbon selection lever on the red dot and, if necessary, reform any parts of the mechanism to have them function properly.
6. Move the ribbon selection lever to the blue dot and make corrections, if necessary, as you did in step four.
7. Depress the shift lock key and test for ribbon cover by typing a few capital H's (HHHH) in both black and red. The H should strike in the center of the black and red portions of the ribbon. If the type strikes too high on the ribbon, so adjust the ribbon U-bar eccentric that its high point is slightly toward the bottom of the machine. If the type is striking too low, reverse this procedure. Then test for ribbon cover again by typing the entire alphabet and figures in both upper and lower case. To prevent overthrow or underthrow of the ribbon, you must CORRECTLY ADJUST THE ECCENTRIC. If two or three keylevers throw the ribbon too high or too low, make correction by forming the corresponding fingers on the ribbon U-bar.
8. Place the ribbon selection lever on the black dot and so adjust the black upstop screw that the ribbon U-bar has just a little downward movement left.
9. Put the ribbon selection lever on the red dot and so adjust the ribbon actuator arm stop that just a bit of downward movement remains in the ribbon U-bar.
10. If the ribbon carrier moves when you shift the ribbon selection lever, the fingers of the ribbon U-bar may be too high, the ribbon actuator arm stop may be formed too low, the stud in the ribbon lift bellcrank may not be in line with the hole in the arm, or the high point of the ribbon U-bar eccentric may not be toward the front of the machine.

KEY RESTORER MECHANISM

The type bar restoring mechanism on a Remington standard typewriter releases and restores collided type bars near the type bar guide. Study illustration 3-13. When the restorer key is depressed, it strikes the bellcranks of collided type bars and returns the type bars to their normal rest positions.

When in the rest position, the restorer should not touch the side frame connecting rod (fig. 3-13) adjacent to it; and it should not contact the bellcranks when a center type bar is held against the platen. You can correct either difficulty by forming the key restorer lever connecting shaft where it contacts the restorer.

SHIFT MECHANISM ADJUSTMENTS

When adjusting the shift mechanism, it is very important that you have freedom of movement but minimum end play of all pivot points. Excess end play results in poor ON-FEET and MOTION alignment. (The term ON-FEET means a type bar is so formed that upper and lower case characters on the type heads print with equal density.) You can remove end play in the shift keylever shaft by adjusting the pivot screws on the right side of the frame. Study the illustration of the shift mechanism in the manufacturer's technical manual.

Make ON-FEET and MOTION adjustments in the following manner:

1. Loosen front and rear segment stop screws to prevent their limiting segment travel.

2. Position the high points of the shift toggle eccentrics down.

3. So adjust the shift toggle cushion eccentrics that the toggle levers make a straight line when the type bar segment is in either the upper or lower case position.

4. Depress the shift key and adjust the forward eccentric for on-feet adjustments. Move the high point of the eccentric toward the front of the machine to raise the segment and toward the rear to lower the segment. Check upper case lock; if there is none, recheck step three.

5. Position the front segment stop screw to the extent necessary to remove excess up and down play when the shift key is depressed.

6. Adjust the rear eccentric for MOTION. Then test for motion by typing small and large H's alternately (HhHhHh). Bottoms of all H's must be in line. Check lower case lock and then recheck step three.

7. Position the rear segment stop screw as necessary to remove excess up and down play when the shift toggle is near the latching point. CAUTION: Make certain the eccentric screws are tight.

8. Sufficiently adjust the eccentric below the shift yielding spring to position the top of the shift key 1/16" above the top of the lower bank of keys.

9. Shift lock plates must be set evenly. So position them that motion will be held when the shift keys are in the LOCK position. Both plates should hold the shift key assembly in the same position.

The segment is adjusted at the factory by accurate gages and adjustment is seldom necessary; but if it is necessary, or a bind was put in the segment during shipment, make adjustment by screwing in or out on the RIGHT segment ball race block screws. Retighten the screws when adjustment is complete.

CARD HOLDER ADJUSTMENTS

The transparent card holders on the Remington standard typewriter enable the operator of the machine to insert paper without raising the paper bail. These holders have locking arms which can be positioned to get proper action in accordance with the type of cards or holders inserted into the machine.

When the locking arms are positioned toward the OUTSIDE of the machine, the transparent card holders are held forward, farther away from the platen. When the locking arms are in a vertical position, the card holders are in their normal position; but they can yield forward, if necessary. If the arms are set toward the center of the machine, the card holders are held in their normal position, with NO yielding in any direction.

ALIGNING SCALE ADJUSTMENTS

You can adjust the aligning scale by so forming the aligning scale bracket that six sheets of paper may be placed between the scale and the platen. Type some i's (iiii) and adjust the aligning scale so that there is a fine line of space between its top and the bottom of the printed line of i's. At the same time, so position the aligning scale laterally that the white lines on it will be in line with the vertical lines of the printed i's.

ADJUSTMENTS OF MARGIN, LINELOCK AND BELL

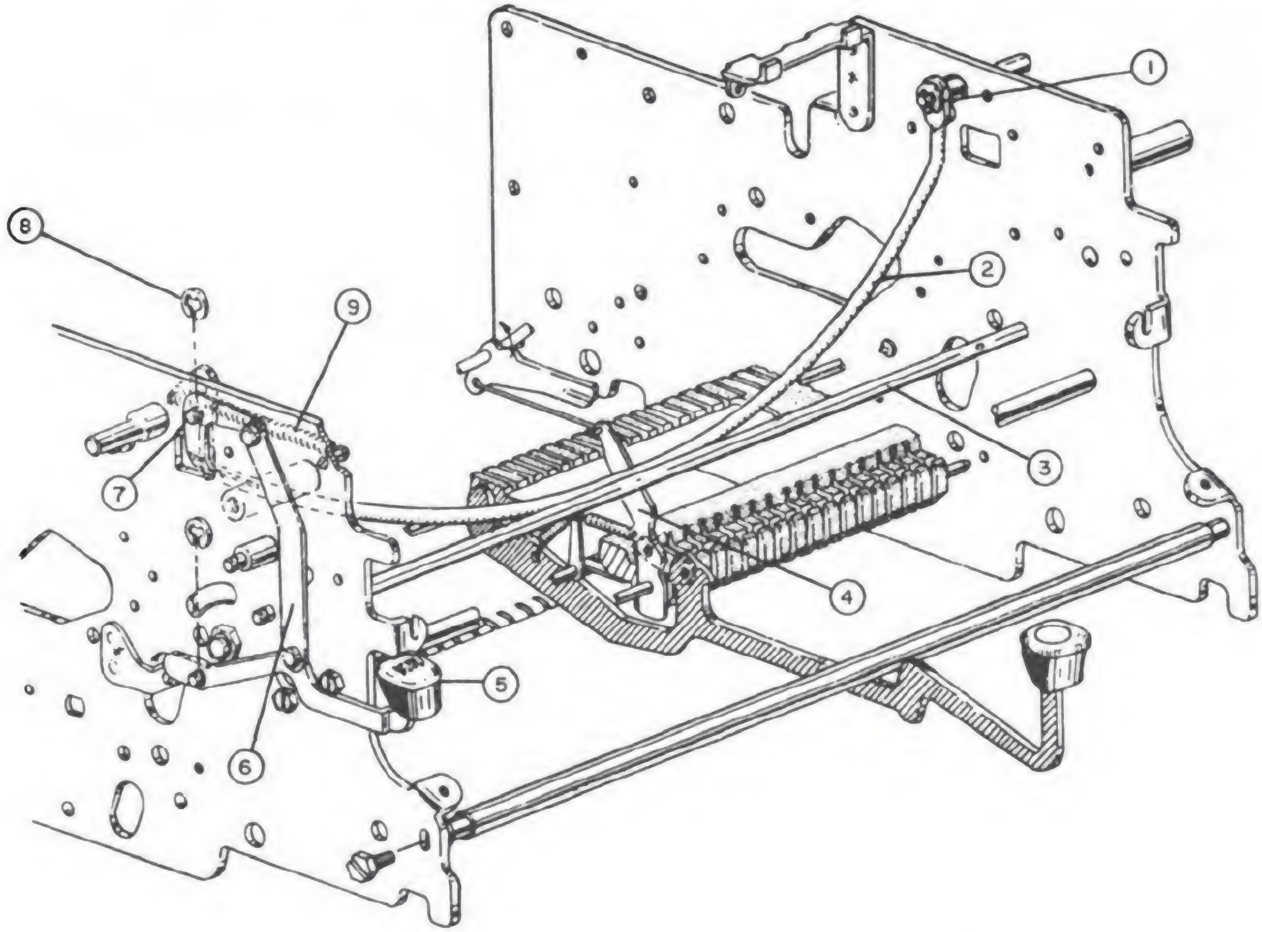
Take another look at illustration 3-6 as you study the procedure for adjusting the margin release and linelock mechanism.

Adjust the margin release toggle connecting arm (margin release push link also, if necessary) to the extent necessary to have the margin stop release blade clear the stop plates of the right and left margin stops. CAUTION: You must not have too much clearance.

Position the margin stop rack as necessary to have the left margin stop clear the margin stop release blade by .050" to .060" when the carriage is to the right. Move the left margin stop inboard and check from the front with a feeler gage. Recheck the 6'oclock position. Position the rubber stop the amount required to have it absorb the shock from the carriage as it returns to the left margin. Adjust the margin blade buffer cushion (rubber eccentric) as necessary to have it JUST CONTACT the margin blade buffer.

The bell should ring 8 to 10 spaces before the line is locked. You can make proper adjustments by moving the bell slide cam to the right or to the left.

When the carriage is against the right margin and the keyboard is locked, the linelock adjusting plate should be against the margin stop release blade. Adjust by positioning the linelock adjusting plate eccentric.



1. Restorer pivot stud
2. Restorer
3. Ribbon feed shaft
4. Bellcrank
5. Restorer key
6. Type bar restorer key lever
7. Restorer pivot stud
8. Keeper
9. Type bar restorer spring

91.5X

Figure 3-13.—Key restorer mechanism.

Check your adjustments by tabulating to the right margin and checking the stopped position of the carriage. Then depress the backspace key to determine whether it will move the carriage farther to the right. If the carriage is not in proper position, or if it moves a space to the right when you depress the backspace key, recheck all your previous adjustments of the mechanism.

You can correctly position the escape wheel so as to allow reliable backspacing out of the right margin by:

1. Positioning the left and right stops 20 spaces apart.
2. From the left stop, typing 20 characters.
3. So positioning the adjusting plate that it just touches the margin stop release blade.

The bell mounting hole is off center, to allow for adjustments of the bell. It should be so adjusted that it clears the hammer by about .020 inch. If the bell rings when the carriage is returned, there is not enough clearance between the hammer and the bell. Correct this difficulty by reforming the hammer.

TABULATOR MECHANISM ADJUSTMENTS

The tabulator mechanism of a Remington standard typewriter is shown in figure 3-11.

The tabulator key bar lever, tab set keylever, and the tab clear keylever bellcrank springs must have sufficient tension to hold their respective keylevers against the upstop. The down stops for tab keylevers are the extended portions of the keylever comb.

Make adjustments of the tabulator mechanism as follows:

1. When the tab key is depressed, the tabulator blade should center between the two tab stops. Adjust by positioning the tabulator rack (adjusting screw and lock nut in right end of carriage).

2. The tab set arm should contact ONLY ONE tab stop when the tab set key is depressed. Make adjustments by positioning the tab set bracket.

3. The tabulator bellcrank adjusting screws should just clear their respective blades by about .010 inch. Adjust by turning the screws.

4. When the tabulator clear key is depressed, the top of the tabulator blade must clear the bottom of the tabulator stop rack by 1/32 inch.

5. When the tabulator key is depressed, the TAB CLEAR blade should clear the tab stops in their normal positions. Adjust by turning the tab clear blade bellcrank adjusting screw.

6. The tab set arm should clear the tabs in their normal positions and fully depress a tab stop when the tab set key is depressed. Make necessary adjustments by forming the lips of the tab set arms.

7. The tabulator friction study should seat flush on the star wheel when the tab key is depressed. Make essential adjustments by turning the tab friction arm support screw. If the tab stop blade hangs on a tab stop and will not restore, move the support screw toward the front of the machine to relieve pressure on the star wheel.

8. The tabulator friction stud should clear the star wheel in its normal position. Make required adjustments by forming the lower end of the tab friction screw arm toward the front of the machine.

9. Smooth, rapid travel of the carriage during tabulation can be procured through proper adjustment of the tab friction spring. Turn the adjustment screw as necessary and then lock the nut.

10. When the tab bar is depressed, the loose dog release lip should lower the loose dog JUST ENOUGH to clear the star wheel—not far enough to limit the loose dog in its guide. Form the loose dog release lip enough to get proper adjustment.

LINESPACE AND CARRIAGE ADJUSTMENTS

Before you start to make adjustments on the linespace mechanism, check first to determine whether a shiny platen or glazed feed rolls are responsible for improper feeding of paper.

Linespace Adjustments

When the left platen knob is tight, the variable linespace shaft must have a slight amount of end play. Make tests with the variable set at various positions. Lack of end play prevents the clutch plunger springs from securely forcing the clutch plunger to the cam variable linespace lever dogs into the teeth of the ratchet, which is necessary in order to have even spacing between lines.

Check for freedom (without end play) of the platen in its bushings. To remove end play, loosen the adjustment screw in the right platen knob and turn in on the knob until there is no end play in the platen when you spin it. Retighten the screw. Study different parts in the two illustrations.

The linespace pawl arm on the Remington standard typewriter has been extended forward, and a hardened button stud has been added to the linespace regulator to contact the arm, eliminating the link formerly used. The linespace lever works in conjunction with the carriage end panels.

With the paper bail raised, the feed roll release lever pulled forward, and the linespace regulator set to the rear, move the linespace lever slowly to the RIGHT. Observe the engagement of the rear portion of the linespace pawl with the teeth of the ratchet and the lower portion of the linespace pawl with the platen ratchet. Hold the linespace lever to the right as far as it will go and try to turn the platen. It is securely locked in position. At this point, adjust the ratchet detent arm eccentric enough to have the detent roll resting between two teeth of the platen ratchet. This is a very important adjustment, for the detent must hold the ratchet in the position placed by the linespace lever.

The linespace ratchet detent arm spring must have enough tension to centralize the detent roll between two variable linespace ratchet teeth when you turn the platen slightly forward or rearward. You can make proper adjustment by positioning the spring anchor eccentric.

Operate the linespace lever to its limit and release it slowly, observing at the same time whether the platen ratchet creeps slightly to the front or to the rear of the machine. Then test the machine with the linespace regulator set at the DOUBLE and TRIPLE space positions.

To check the pressure exerted by the front and rear feed rolls, place two small strips of paper 1'' wide between the platen and the rear outside feed rolls, but not far enough in for the front feed rolls to grip them. Then pull on each strip alternately to determine whether the rear feed roll has a firm, even tension at both ends. Adjust rear feed roll pressure springs as necessary to get even pressure. Make this same test on the front feed rolls and adjust as necessary to get proper pressure.

Even pressure of the bail roll on the platen can be obtained by correctly forming the bail arms.

Adjustment of Carriage Scales

When you make adjustments on carriage scales, set the left margin stop to the extreme left end of the carriage.

The carriage scale is mounted in the same manner as the paper bail scale, and the adjusted carriage scale can be used to set the paper bail scale.

So position the carriage that zero (red figures) is in line with the pointer on the type guide. Put paper in the carriage and place a pencil in the slot of the type guide (top). With the point of the pencil against the paper, rotate the platen. Your vertical mark on the paper should be in line with zero on the paper bail scale. If this is not true, loosen the screws at both ends of the paper bail scale and adjust as necessary to get this condition. If necessary, re-form the paper bail arms.

The aligning scale should be distant from the platen the thickness of six sheets of paper. It should be .005'' below the writing line, and its white lines should line up with the letter I. Make proper adjustments by loosening the screws and positioning the scale.

Paper Table and Margin Stop Scale

To adjust the paper table, put a sheet of 8 1/2 x 11 paper in the typewriter and turn the platen until both ends meet above the platen. Adjust the top edges and corners to get proper alignment. Release the feed roll lever and check to ascertain whether the numbers and graduation marks on the front scale of the paper table correspond with the upper half of the carriage scale and bail scale. If they do not correspond, unloosen the two nuts on the underneath side of the paper table and make proper adjustment.

CARRIAGE ADJUSTMENTS

The carriage support brackets are mounted to the underside of the bed rail by two screws. The inside slots of these support brackets have elongated holes for screws, and at the rear of the brackets are eccentrics which are used to adjust the carriage to the front or back to obtain cylinder and anvil position. They are correctly adjusted when the carriage is parallel to the machine; and when the type bars are held at anvil position, with one sheet of paper in the carriage, the type should bite the strip of paper at the platen and anvil with the same pressure.

When adjusting the carriage, follow these rules:

1. So adjust the carriage support rail that the bottom of the rail just touches the lower carriage support rail roller. Make necessary adjustments by lowering or raising the carriage support rail.
2. Adjust and position the carriage feed rack to the extent necessary to have it mesh evenly and fairly deep (never to the bottom) with the escape wheel pinion.
3. So adjust the carriage support rail roller that it barely clears the top of the carriage support rail. This clearance should be exactly .002 inch.

ESCAPEMENT ADJUSTMENTS

Refer to the escapement mechanism shown in figure 3-4 as you study the procedure for adjusting it. First, adjust the feed rack to the degree necessary to have its teeth mesh fairly deeply and evenly in the teeth of the escape wheel pinion. CAUTION: If these teeth BOTTOM in the teeth of the escape wheel pinion, piling of letters and a noisy carriage result. Move the feed rack up and down on the feed rack mounting screws, as necessary, until you have proper adjustment.

To adjust the loose dog silencer, loosen the set screw which holds it and turn the adjusting threaded collar until you have proper tension, just enough to hold the loose dog clear of the

escape wheel teeth as the carriage is returned. CAUTION: The rear side of the adjusting collar should not extend beyond the back edge of the escape wheel. TOO MUCH tension causes sluggish operation of the carriage. Re-tighten screws in the collar when the tension is as desired.

So adjust the escapement loose dog carrying arm screw that you have a minimum amount of play. Check the loose dog for freedom of movement in the loose dog guide, up and down and right or left. The correct distance between the loose dog and the rigid dog is from .043 inch to .045 inch.

Hold the face of the loose dog flush against the teeth of the escape wheel (commonly known as 6 o'clock condition) and adjust for this condition by moving the escapement rocker pivot screws to the right or to the left to get desired results. Then check for freedom of action of the rocker, with NO end play.

Raise the H type bar to the ribbon. The escapement should trip as soon as the face of the type touches the ribbon. To adjust, loosen the escapement link nut and adjust the escapement link sleeve in the amount necessary to have the trip take place when a typeface touches the ribbon. If all type bars do not trip at the same position, adjust the ends of the U-bar to center the type bars.

Hold a type bar head against the platen and check the lower part of the escapement rocker for a small amount of additional forward movement. (The upper escapement stop screw should not limit the movement of the escapement rocker.) Then make the same test with the spacebar depressed against its down stops. If forward movement of the escapement rocker is not the same, check all spacebar adjustments and test again. If the rocker still limits against the upper stop screw, turn this screw slightly counterclockwise.

To test the escapement SAFETY ZONE, raise the H type bar slowly by hand until it touches the ribbon and escapement takes place. Then allow the type bar to restore slowly to its rest position (front). The second trip should occur when the face of the type bar is 1/2" to 9/16" away from the ribbon. If the distance is more than 9/16", letters may pile on top of each other; if the distance is less than 1/2", skipping between letters may occur. Check the distance between the loose and rigid dogs to make certain that it is between .043" to .045". If the escapement loose dog carrying arm screw is TOO tight, it prevents the loose dog from stepping to the left, causing the machine to pile up letters occasionally.

ADJUSTMENTS OF TYPE BAR U-BAR

To test adjustment on the type bar U-bar, raise the H type bar to the ribbon and check the escapement action. If this is correct, raise by hand type bars No. 1 and No. 42 to ascertain whether escapement takes place when the face of the type touches the ribbon. If all three type bars cause the escapement to trip when the typeface touches the ribbon, the U-bar is correctly adjusted.

If the No. 1 type bar were to cause the escapement to trip when it was still 1/8" away from the ribbon, you would make correction by loosening the left type bar U-bar oscillator pivot screw and lock nut and moving the screw slightly to the rear. After you make this adjustment, always check No. 42 type bar for trip action. When you move the LEFT type bar U-bar oscillator pivot screw to the rear, escapement on No. 42 type bar occurs a little sooner than it did before. When you move the LEFT type bar U-bar oscillator pivot screw forward to make escapement on No. 1 type bar occur sooner, it causes escapement on the No. 42 type bar to occur later.

Adjustment pivot screws are provided at both ends of the type bar U-bar oscillator bracket. If escapement on the No. 42 type bar does not take place at the ribbon after you locate the left type bar U-bar oscillator pivot screw, follow the same procedure for properly locating the RIGHT type bar U-bar oscillator pivot screw.

PLATEN ADJUSTMENTS

The platen should turn freely, with no noticeable end play. Adjust by turning the right platen thumb wheel. You can remove up and down play from the platen by adjusting the platen lock lever eccentric.

The paper feed rolls should have enough tension to cause the platen to turn as you pull a single sheet of paper from the machine; and all feed rolls should have equal tension. Adjust feed roll tension by turning the feed roll tension spring screws.

Paper bail rolls should seat on the platen. Make necessary adjustments by forming the paper bail assembly arms. The paper bail scale can be adjusted laterally to line up with the margin scale. To adjust the scale, loosen the screws and position the scale. Adjust the ring and cylinder with the carriage binding screws and eccentrics (left and right), with one sheet of paper in the machine.

For additional information on adjustments of parts and mechanisms of the Remington standard typewriter, consult the manufacturer's technical manual for the machine.

CHAPTER 4

ELECTRIC TYPEWRITERS

This chapter discusses the operation of an electric typewriter and gives some of the procedure for adjusting it. To qualify for advancement in rating to Instrumentman 1, you must understand how an electric typewriter works and be able to adjust it; and in order to qualify for advancement in rating to a Chief Instrumentman, you must know how to analyze and remedy casualties to these machines.

Space in this text does not allow a detailed discussion of several makes and models of electric typewriters, but one representative make is discussed in sufficient detail to enable you to understand how it operates. All typewriters have parts which are similar, but they do not operate in the same manner. All electric typewriters have motors which provide power for operating parts and mechanisms, but the parts are not all alike in design nor do they function exactly the same. The best way to learn these differences, therefore, is by working on the typewriters, with the manufacturer's technical manual for a particular model available for ready reference. Some similarities and differences are pointed out in this chapter.

Study the nomenclature of the Smith-Corona electric typewriter illustrated in figure 4-1. Then take a look at the Royal electric typewriter shown in figure 4-2. Figure 4-3 shows an IBM electric typewriter (executive model), which differs slightly in construction from the Model C-1 machine selected for discussion in this chapter.

PARTS AND MECHANISMS

Before you can understand the operation of an electric typewriter, you must know and understand the function of various parts and mechanisms which comprise it. These are discussed first, and illustrations are given in sufficient number to enable you to understand how the mechanisms function. By studying each illustration as you read the discussion applicable to it, you will get a clear picture of the operation of an electric typewriter and understand how its parts and mechanisms differ from those of a manual typewriter.

MOTOR AND ELECTRICAL SYSTEM

The heart of an electric typewriter is the motor and electrical system (fig. 4-4). The motor (115V-60 cycle) is rated at 1/40 horsepower and runs at a speed of approximately 1625 revolutions per minute (rpm). No governor, brushes, or starting contacts are required. The capacitor in the starting winding circuit provides starting torque and direction to the motor. Except for the switch, the entire electrical system is mounted on the rear frame, making it readily accessible for inspection by removing the frame.

Figure 4-5 shows how the power from the motor is transmitted by belts and pulleys to the power roll. Note the names of the two belts, and the teeth on them. Speed reduction from the motor to the power roll is approximately 6:1. Different combinations of pulleys give different speed reductions. Power roll speed can be varied by using pulleys of different size on the motor, two sizes of which are available in the C-1 machine. A 14-tooth pulley provides a power roll speed of 242 rpm, or 95 feet per minute (fpm). A 15-tooth pulley provides a power roll speed of 261 rpm, or 103 fpm.

POWER ROLL

The purpose of the power roll is to drive the cams (explained later) which operate the type bars and perform other functions. This roll consists of a rubber sleeve glued over a metal cylinder. Serrations of letter and functional cams engage the rubber surface of the

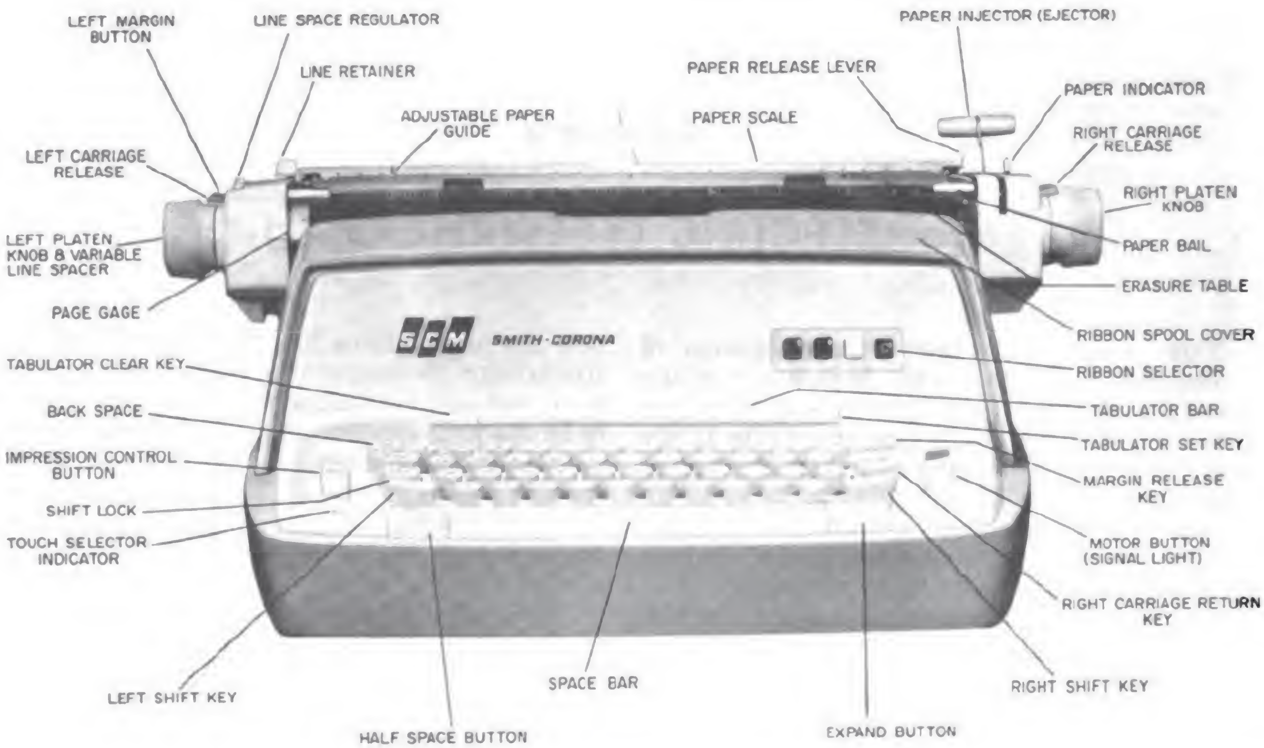


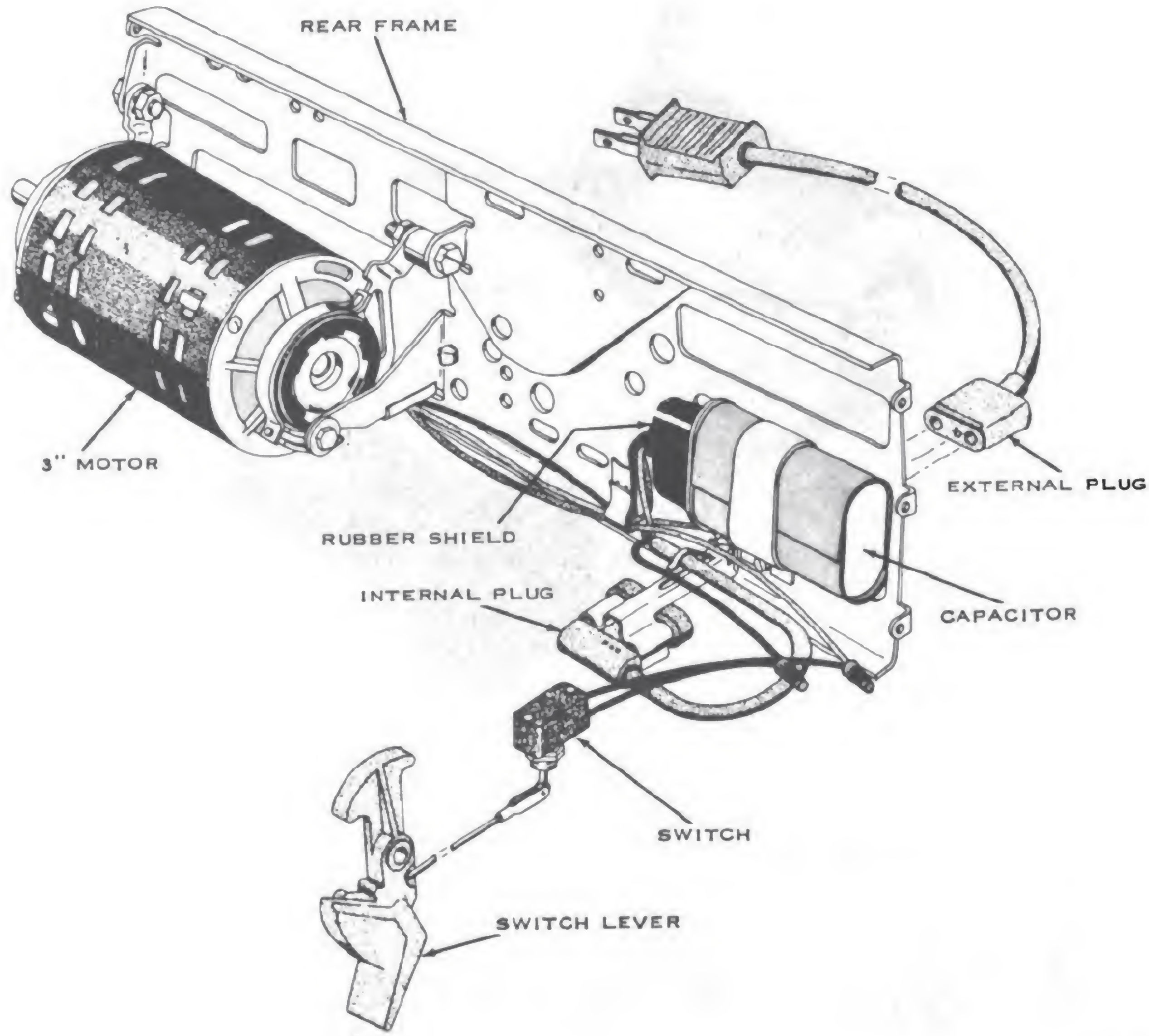
Figure 4-1.—Smith-Corona Electric Typewriter. 61.37X

61.37X
Figure 4-2.—Royal Electric Typewriter.

61.37X
Figure 4-3.—IBM Electric Typewriter.

power roll and move with it. The complete power roll assembly is shown in figure 4-6.

The rubber covering of the power roll must be resilient enough to ensure good friction with the cams and at the same time tough enough to resist wear and abrasions from the cams. An anti-oxidizing wax added to the rubber gives it these qualities and prevents hardening. Eventually, however, it becomes too hard to give good impressions and the roller must be replaced. The wax goes to the



91.6X

Figure 4-4.—Motor and Electrical System.

surface of the power roll and lubricates it; but it also gets on the cams and clogs their serrations, and builds up deposits on their sides. Wax on the surface of the roll may cause impression difficulties, and wax on the sides of the cams may cause repetition. It is therefore advisable to clean the surface of the power roll when it is installed and at periodic intervals thereafter.

LETTER KEYLEVERS

The method of mounting keylevers in the IBM electric typewriter is illustrated in figure 4-7. They are supported at the rear by a fulcrum rod which passes through a hole in each keylever. The fulcrum rod is held at each end by the keylever bearing support which is mounted to the side frames. The forward end of the keylever bearing support may be raised or lowered to adjust the height of the keylever fulcrum rod, and to allow for adjustment of clearance between keylever lugs and the cam trip levers.

The keylever guide comb serves to space and control the forward ends of the keylevers. Keylever springs (fig. 4-7) hold the keylevers in

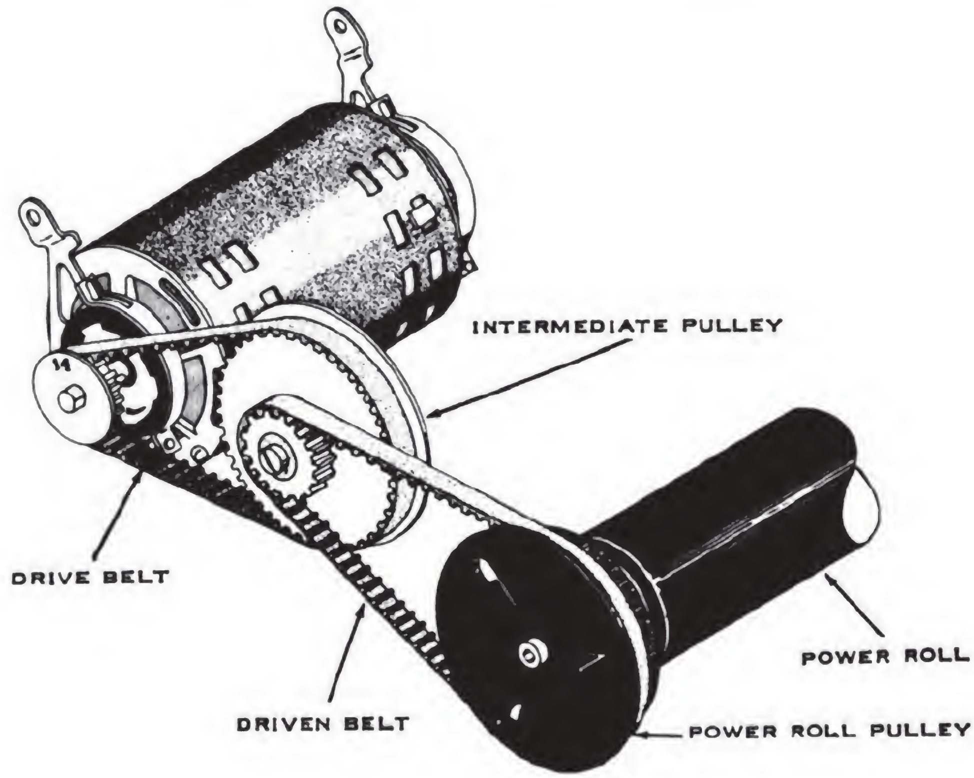


Figure 4-5.—Positive Belt Drive. 91.7X

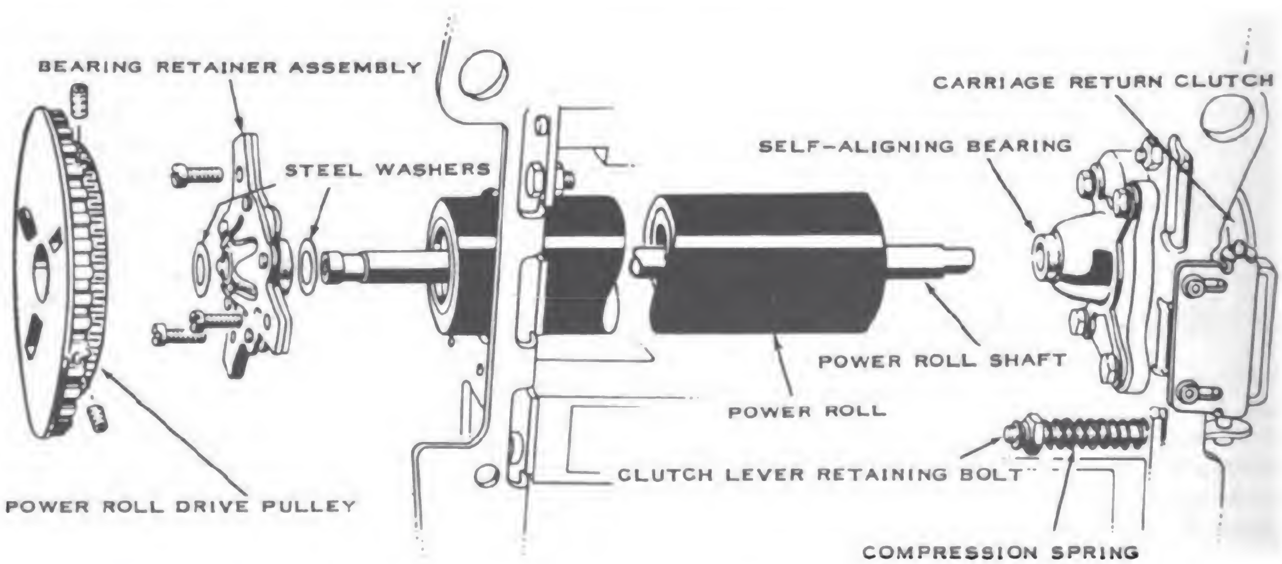


Figure 4-6.—Power Roll Mechanism. 91.8X

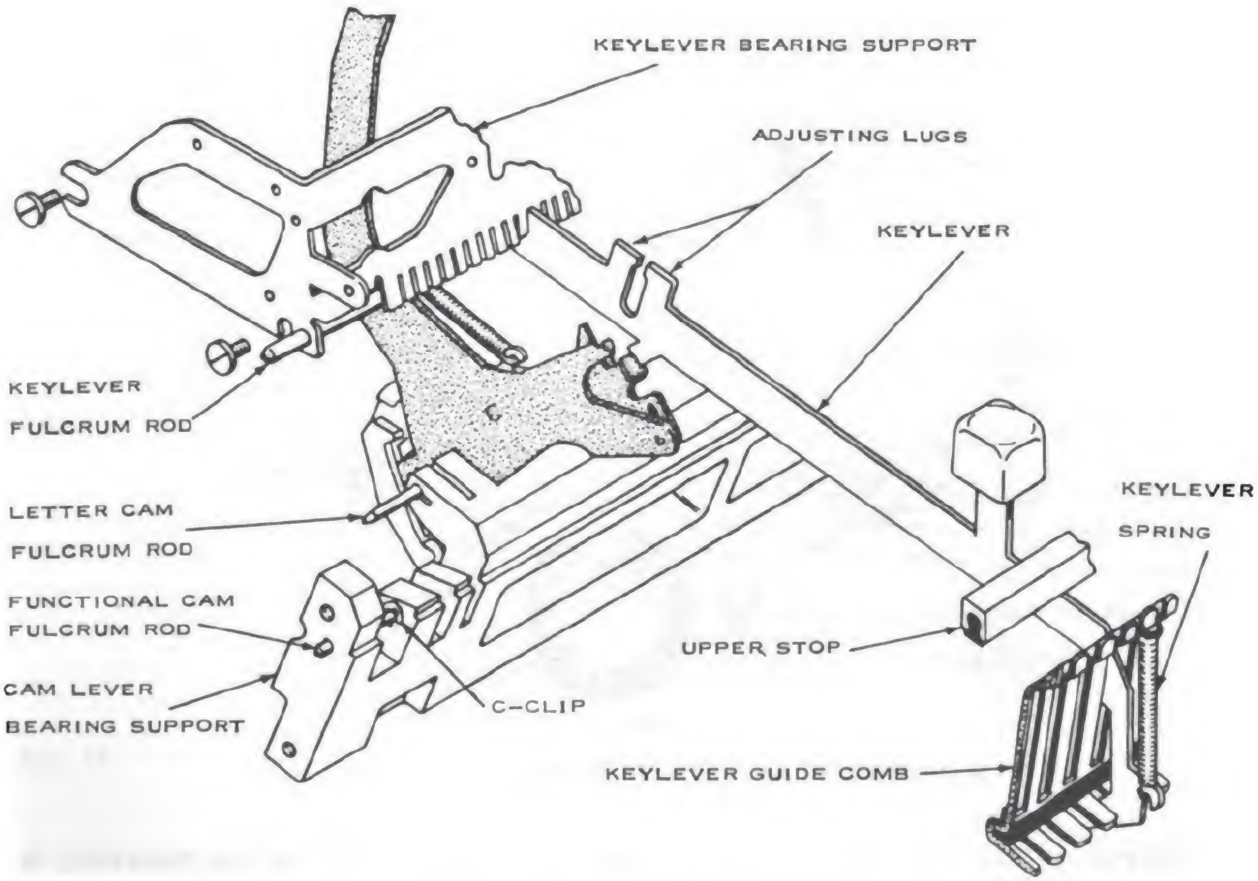


Figure 4-7.—Keylever Mounting. 91.9X

their rest positions against the upper stop, located between the third and fourth rows of keylevers. To provide uniform touch, a spring of different tension is used for keylevers in each row of the keyboard.

LETTER CAMS

Cam letter assemblies are mounted in slots in the cam bearing support and are held by a fulcrum rod which passes through a hole in each cam lever. Study figure 4-8 carefully. A link connects the type bar with the cam lever.

Cams are made of nylon molded over a steel body. The nylon reduces wear and requires no lubrication. The steel body gives rigidity and maintains uniform cam size during temperature and humidity changes. As illustrated, the cam is mounted to the cam lever by a shoulder rivet about which it rotates. A cam spring from the cam to the cam lever holds the cam in its rest position. The heel of the nylon shoe contacts the cam lever when the cam is fully rotated and limits its rotation. In normal operation, however, the cam does not rotate this far; its head contacts the knockout finger and knocks the cam off the power roll before it reaches this limit. The rise of the cam, pushing from the power roll against the cam rivet, causes the cam lever to pivot about its fulcrum.

Note the trip lever. It is mounted to the cam lever by a shoulder rivet through a slot in the trip lever. This slot allows the trip lever to slide forward and backward on the rivet and also to rotate about it. A spring holds the trip lever up and to the rear in its rest position. The trip lever has two formed lugs, upper and lower. The upper lug is positioned directly beneath the keylever lug, and the lower lug is directly above the cam. After the type bar strikes the platen, the type bar and cam lever reverse direction and return to the rest positions.

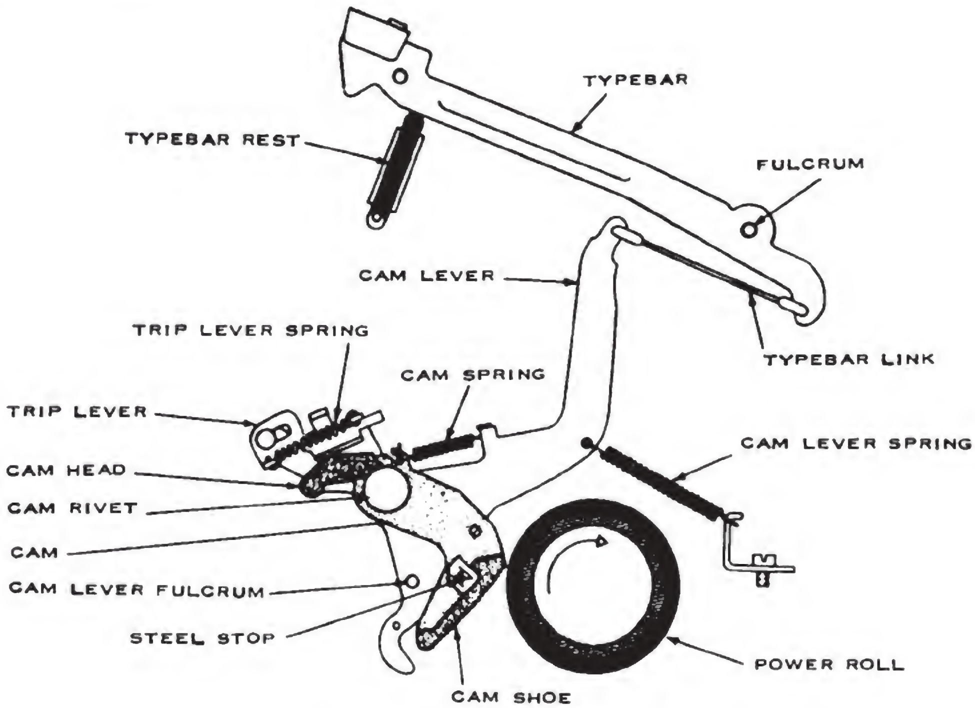


Figure 4-8.—Cam Lever Assembly and Type Bar.

91.10X

If a keylever is held down, the rear edge of the upper lug on the trip lever engages the front edge of the lug on the keylever as the cam lever assembly restores. See figure 4-9. The trip lever slides on its mounting stud as the cam lever restores to its rest position, and remains against the front of the keylever lug until the keylever is raised. When the keylever is raised, the trip lever spring restores the trip lever to the rear beneath the keylever lug. This sliding action of the trip lever ensures a single operation of the cam and allows the type bar to restore to its rest position, even though the keylever is held down.

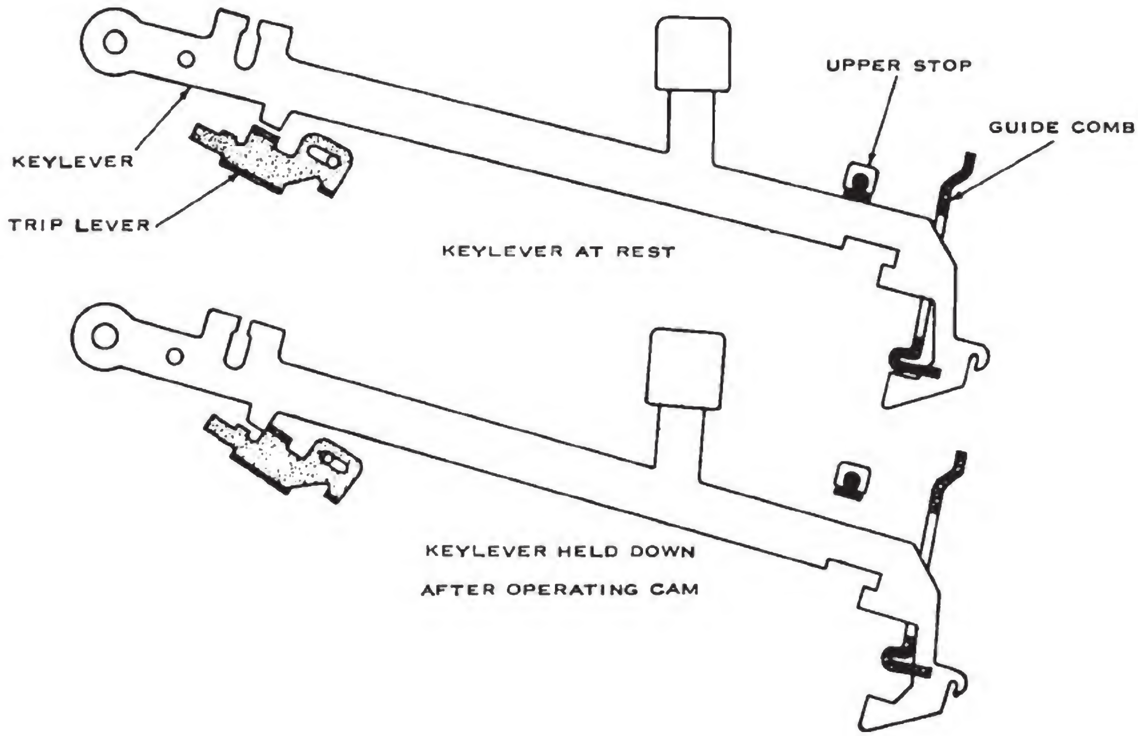
The position of the cam knockout fingers (fig. 4-10) controls type impression. Note the individual cam adjusting screw, one of which is below each knockout finger. By raising or lowering the entire cam knockout assembly as a unit, an operator can change the knockout point of all the cams. This can be accomplished by rotating the impression control lever, which rotates the eccentric shaft to raise or lower the knockout bar. Raising the bar decreases the impression of all type bars; lowering the bar increases the impression of all type bars. The scale on the impression control lever is graduated from 0 to 10, but the typewriter is adjusted at the factory for uniform impressions when the control lever is set at 5.

TYPE BAR SEGMENT

The type bar segment is a semicircular steel casting with slots cut into it to mount and guide the type bars. It also provides the mounting for the universal bar and the type guide, which is formed of heavy metal and attached to the segment by screws and a dowel pin (fig. 4-11).

Note the ring in the segment. As a type bar approaches printing position, it rises through its slot and the type slug enters the type guide. Just before the typeface contacts the paper on the platen the type bar strikes the ring of the type guide (fig. 4-11), which whips (bends) the portion of the type bar above the ring and causes the typeface to print. This whipping action prevents lingering of the typeface on the paper and smearing the impression it made.

The relationship between the type bar, ring, and platen is known as RING AND CYLINDER. This is something important to remember when you adjust the typewriter. Ring and cylinder adjustment is correct when the space between



91.11X

Figure 4-9.—Keylever and Trip Lever Action.

the typeface and the platen (with ribbon and paper in position) is .003 inch. Study figure 4-12.

The IBM electric typewriter has changeable type bars which can be hooked onto the fulcrum wire. Spring tension of the U-bar helps to hold them in position during printing, and a special type bar link with a spring clip is also used on them.

KEYLEVERS.

You are aware of the characteristics of keylevers used on manual typewriters, but the keylevers considered here are the repeat and non-repeat types used on the IBM electric machine. A two-piece keylever is used for field installation of a repeat/non-repeat character in any letter position desired.

When a repeat/non-repeat keylever is depressed to the limit in the front guide comb, the rear step on the keylever lug provides a single operation of the cam, as shown in parts A and B of figure 4-13. If the keylever is held down in this position, the rear step on the keylever lug prevents the trip lever from restoring to the normal rest position. Further depression of the keylever is possible because of an enlarged fulcrum hole and the repeat spring. When the fulcrum point of the keylever is lowered, the repeat stop of the trip lug depresses the trip lever and allows repeat action by the cam. If the keylever is held in this position, the trip lever is cammed down by the front step on the keylever lug each time the cam lever assembly restores from a former operation, as illustrated in part C of figure 4-13.

Now that you have studied the parts and mechanisms from a keylever to a type bar, let's see what happens when a key button is depressed.

When a typist depresses a letter key button, the keylever pivots about the fulcrum rod in the keylever bearing support (fig. 4-14), and a lug on the bottom of the keylever contacts the top lug of the cam trip lever. The trip lever is riveted to the cam lever and pivots down against the cam, causing it to engage the power roll. The distance between the toe of the cam and its shoulder rivet is greater than the distance between the heel of the cam and the rivet. This

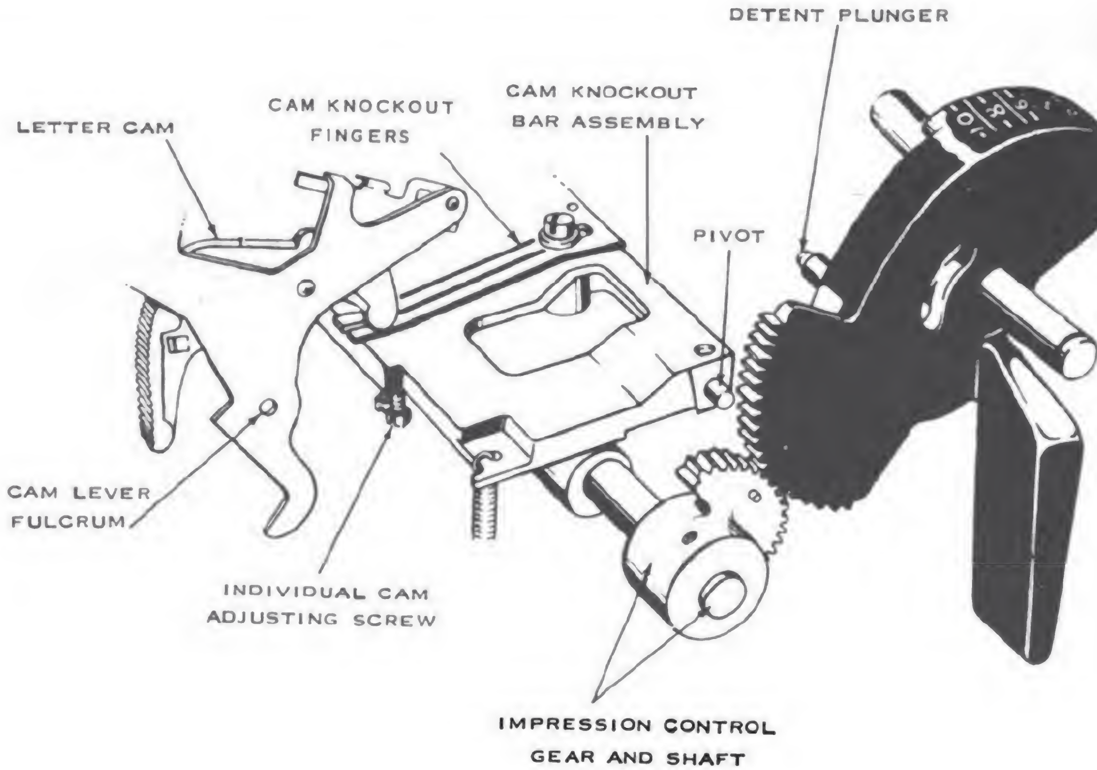


Figure 4-10.—Impression Control Mechanism.

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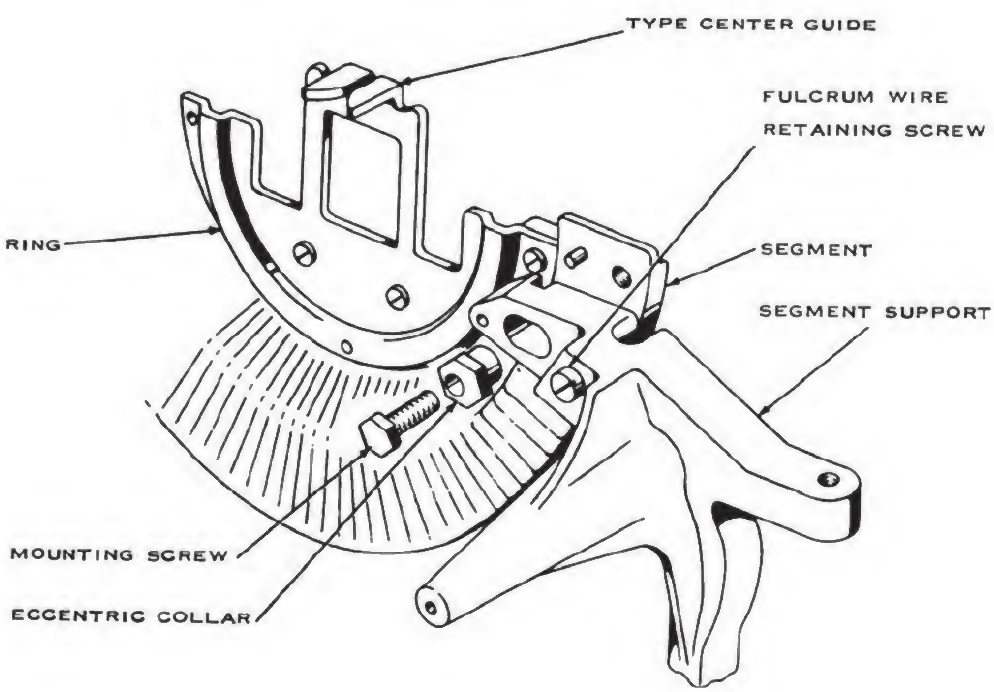

Figure 4-11.—Segment Mounting.

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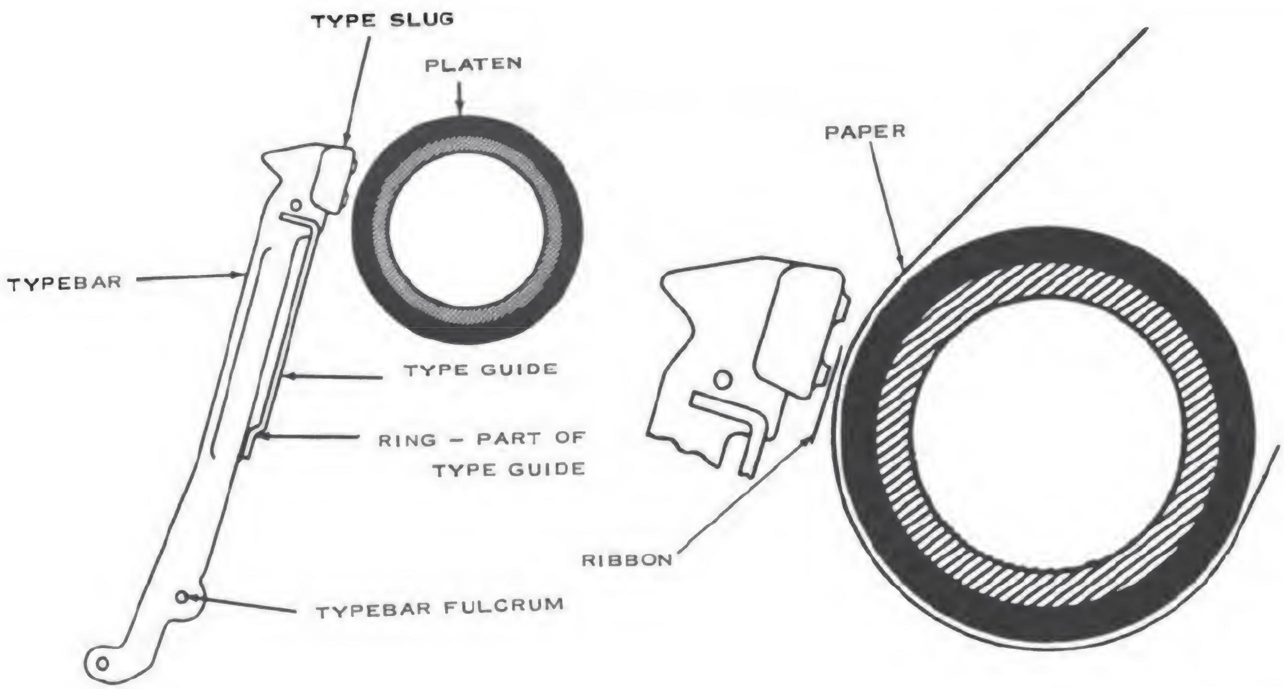

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Figure 4-12.—Type Bar, Ring and Cylinder.

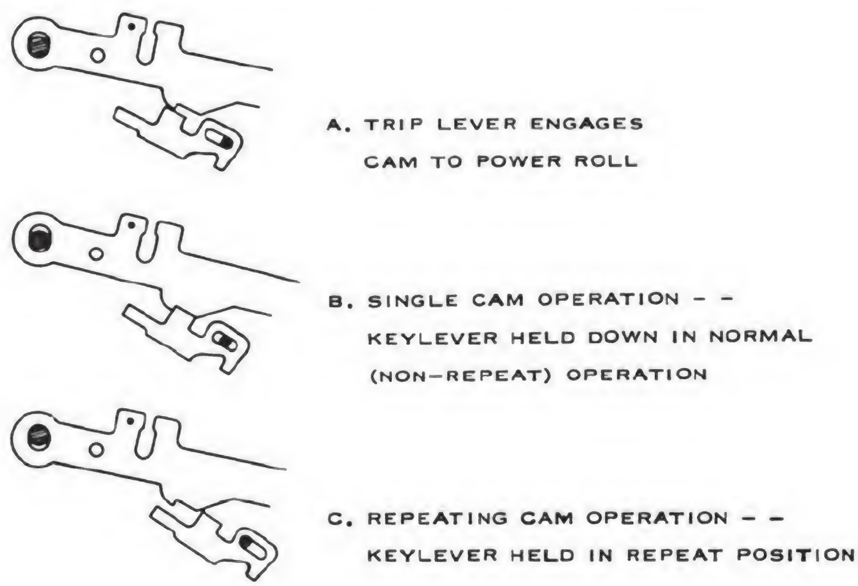

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Figure 4-13.—Repeat Keylever Action.

is called the RISE OF THE CAM. As the power roll causes the cam to rotate, the rise of the cam forces the cam lever assembly to pivot about its fulcrum (cam lever fulcrum rod). The cam lever action pulls on the type bar link and pivots the type bar on its fulcrum wire, which drives the typeface toward the platen.

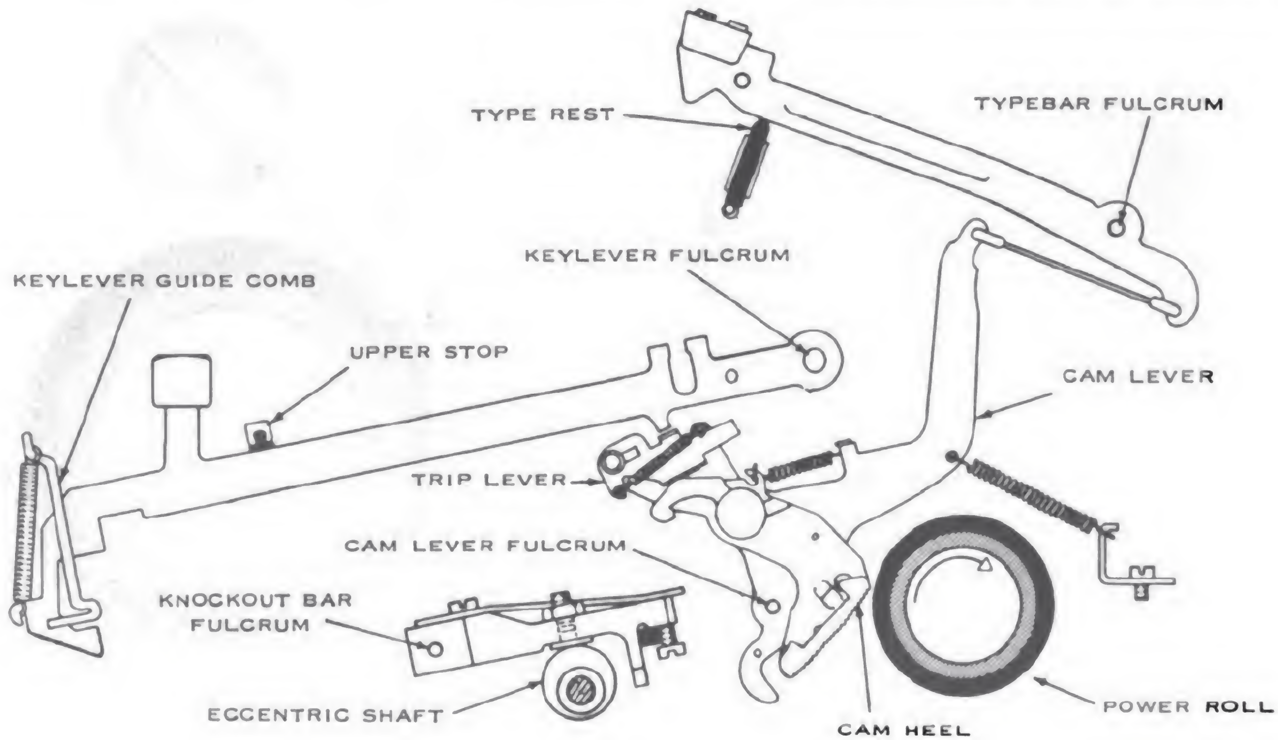

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Figure 4-14.—Cam and Type Bar (Rest Position).

Before the typeface reaches the platen, the head of the cam contacts the cam knockout finger, as shown in figure 4-15, which stops the rotation of the cam. The momentum of the type bar, however, continues the motion of the cam lever and the type bar to the platen. The continued motion of the cam lever releases the nylon cam from the power roll and the cam spring restores the cam to its rest position against the cam lever.

THE ESCAPEMENT

A typewriter carriage moves from right to left under spring tension. The position of the carriage in the IBM electric is controlled by a single pawl (fig. 4-16) engaged in a toothed rack secured to the bottom of the carriage. Operation of the pawl to allow the carriage to move one space at a time is known as ESCAPEMENT. The escapement is operated by a type bar moving toward the platen or by the spacebar. Refer to figure 4-16 as you study the escapement.

Escapement Operation

When a type bar moves toward the platen, it contacts the U-bar and pushes it rearward. The motion of the U-bar is then transferred to the escapement trip link by an adjusting plate (fig. 4-16). Motion of the trip link rotates the escapement trip lever, causing the top of the lever to move toward the front of the machine. The top of the trip lever pushes on an upright lug of the escapement pawl spacer and pivots the spacer forward. Part of the spacer upright lug is behind the tail of the escapement pawl and carries the tail of the pawl forward. The escapement pawl then pivots enough on its mounting stud to pull the pawl tip out of the escapement rack.

When the escapement pawl tip is free of the rack teeth (fig. 4-17), the escapement pawl spring pulls it to the right and into the next tooth of the rack. (Note rivet through elongated hole in the pawl.) Because of its relatively heavy mass and inertia, the carriage does not move until the pawl tip is safely positioned on the next rack tooth. As the pawl is pulled to the right, its tail clears the upright lug of the spacer (fig. 4-17). The spacer then continues to move forward until the type bar reaches the platen. A

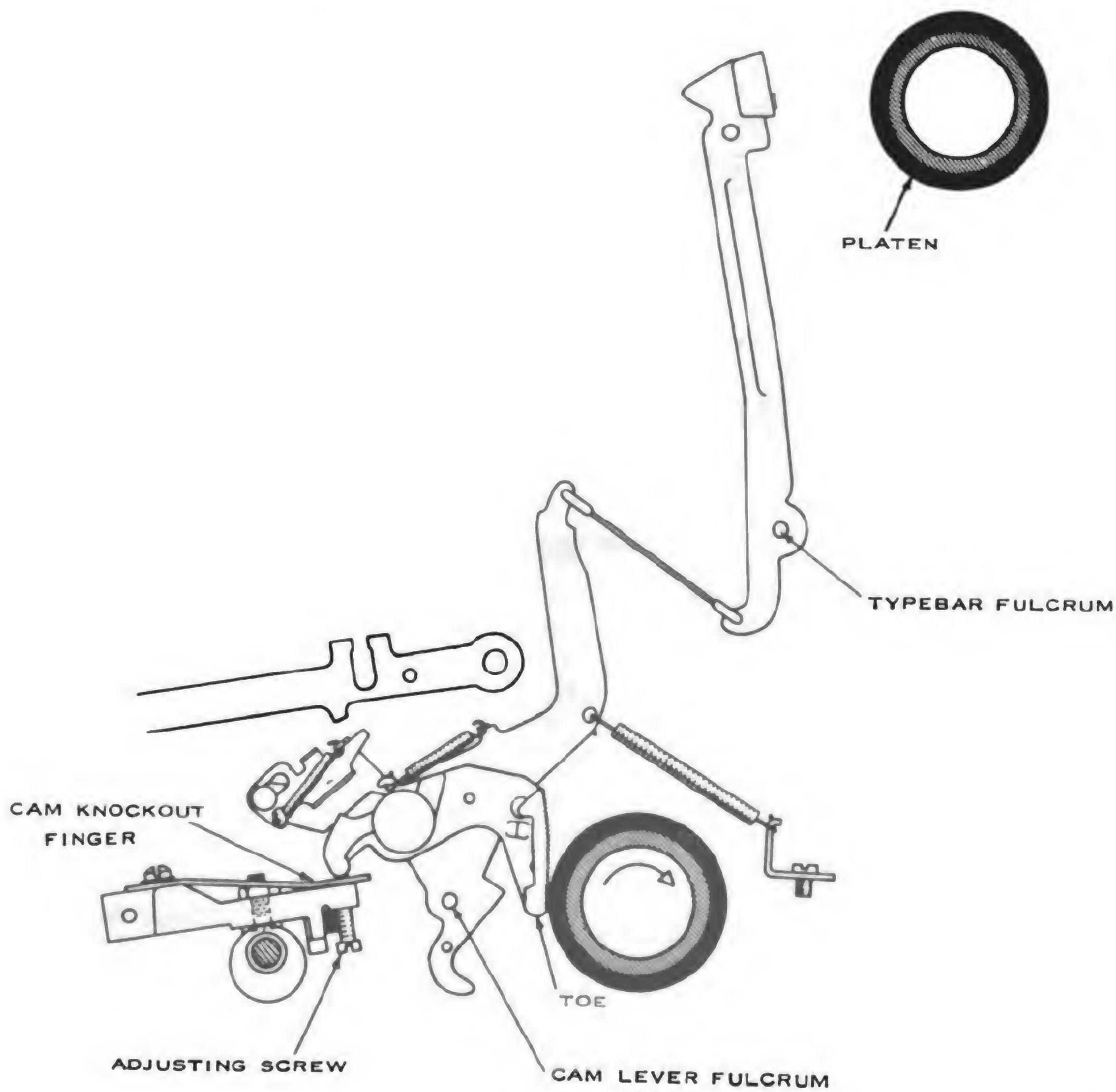

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Figure 4-15.—Cam and Type Bar (Knockout Position).

portion of the escapement pawl mounting bracket serves as an overthrow stop to prevent the spacer from getting in front of the pawl tail. When the type bar reverses direction after printing, the pawl spacer spring restores the spacer to the rear and behind the pawl tail again.

As the carriage moves to the left under tension of the mainspring, the escapement pawl is pushed to the left by the rack tooth until the right edge of its elongated mounting hole contacts the mounting rivet, in which position it stops and holds the carriage. The tail of the escapement pawl is again in position in front of the upright lug of the spacer—one escapement cycle has been completed. (Note that the carriage moves AFTER the type bar prints.)

Escapement Pawl Assemblies

Two types of escapement pawl assemblies are used on C-1 IBM electric typewriter. Machines with 6 2/5 and 14 pitch use an escapement pawl with .038" left-to-right motion. This assembly bears no identification mark. Machines

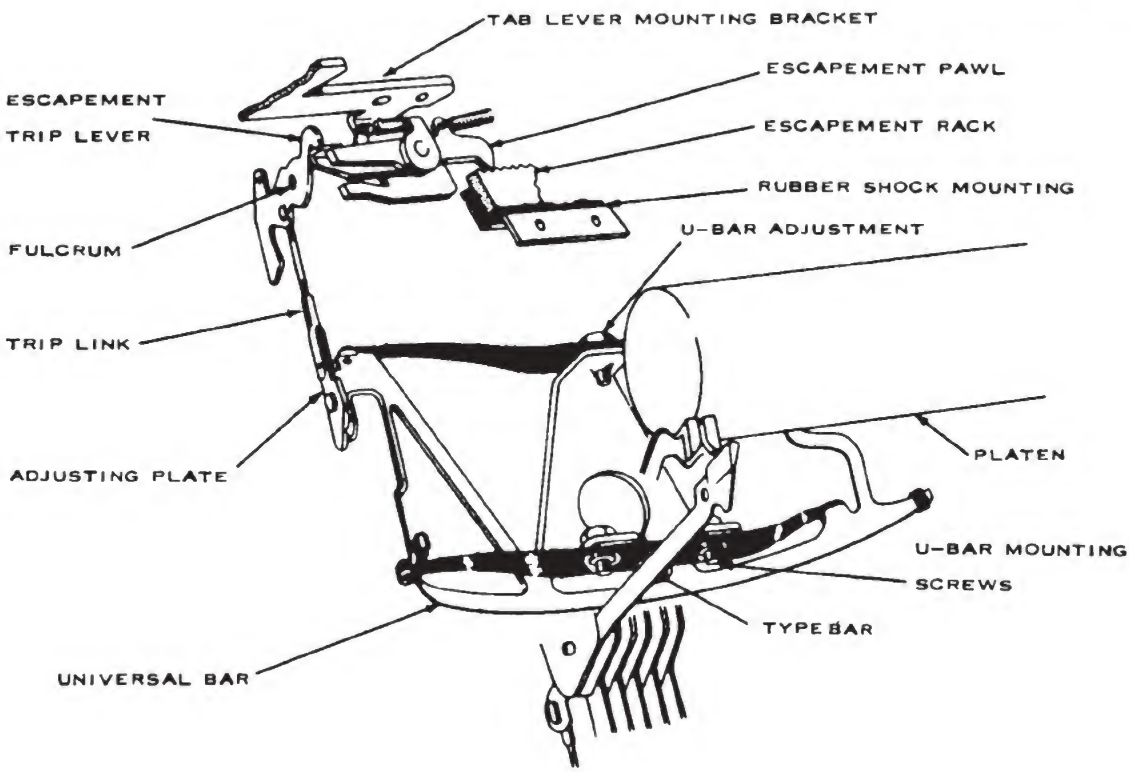

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Figure 4-16.—Escapement Mechanism.

with 8, 9, 10, 11, and 12 pitch use an escapement pawl with .058" motion and a pawl spacer with its upright lug located .027" farther to the right. This assembly is called the FLOATING PAWL and is identified by a notch in the front edge of the pawl and also of the spacer. This type of pawl permits greater typing speed without piling, because the parts come into position sooner than in the other pawl assembly.

The floating pawl travels .020" farther to the right after escapement, because of the greater elongation of its mounting hole. The pawl tip, therefore, must be positioned .020" nearer to the next escapement rack tooth when it re-enters the rack.

Escapement Rack

Spacing of teeth on the escapement rack determines the distance the carriage travels on each escapement operation. The number of spaces or typed characters to the inch is known as the PITCH of the typewriter. The C-1 machines have 6 2/5, 8, 9, 10, 11, 12, and 14 pitch. Pica type is 10 pitch; elite type is 12 pitch.

The escapement rack is screwed and doweled to the bottom of the carriage on all early C-1 typewriters, but the racks in later models with 13" and 17" carriages employ a rubber shock mounting which reduces noise (fig. 4-16).

MAINSPRING

The type of mainspring used on the C-1 typewriter is illustrated in figure 4-18. You learned previously that the function of the mainspring is to provide power to move the carriage when escapement takes place.

The mainspring and holder assembly are mounted to the power frame on a decelerator shaft (fig. 4-18). An ear on the holder contacts a part of the power frame and prevents the assembly from rotating. The drum, which winds the carriage tension tape, also fits on the decelerator shaft and rotates with it. A hook on its hub engages the end of the inner coil of the mainspring. The drum should be rotated to wind the mainspring to proper tension before the carriage tension tape is attached to the end of its outer coil. The other end of the tape is fastened to the right side of the carriage.

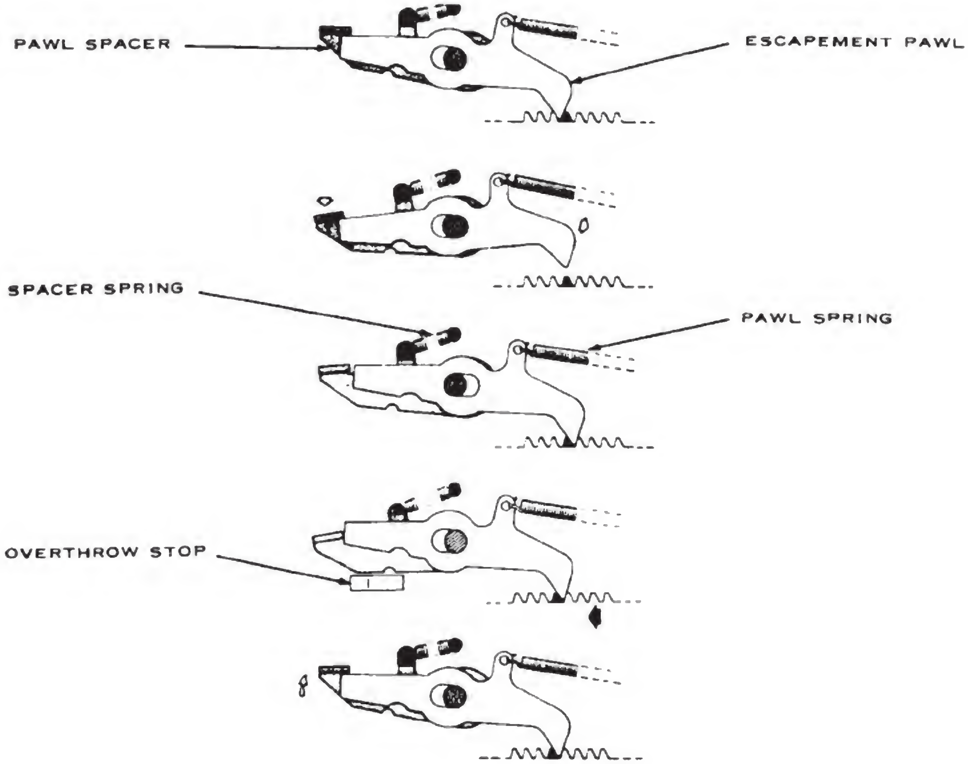

Figure 4-17.—Escapement Pawl Sequence. 91.19X

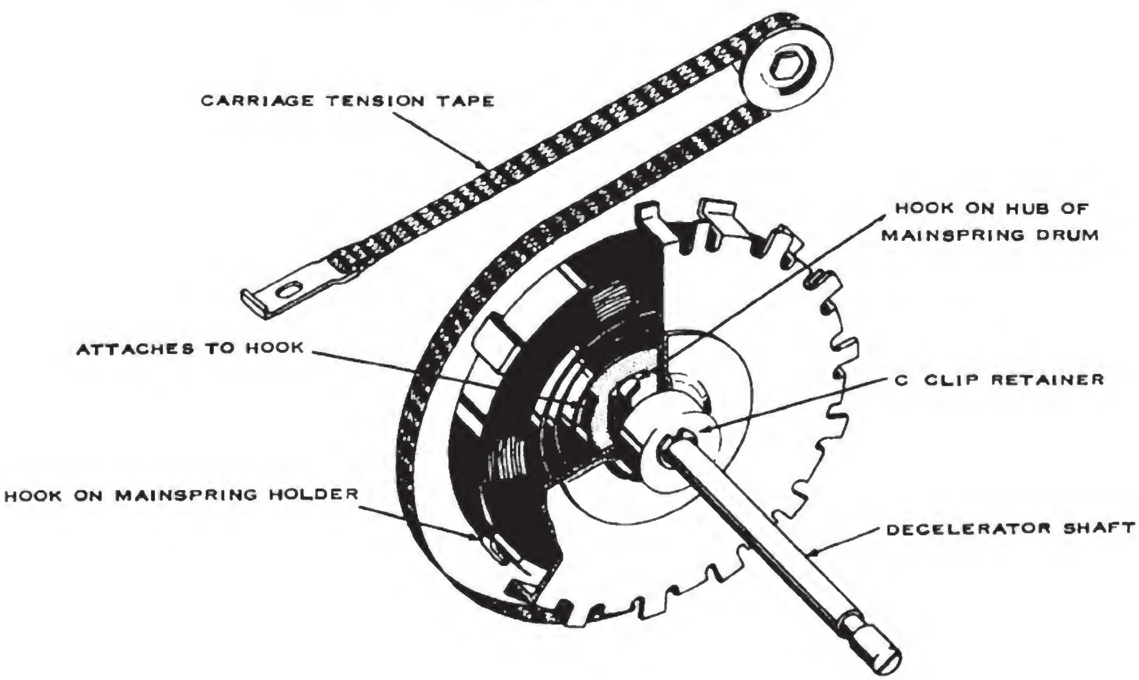

Figure 4-18.—Mainspring, Drum and Tension Tape (Rear View). 91.20X

Use much care when you remove the mainspring drum from the spring. If it is necessary that you separate the drum from the mainspring and holder assembly, be sure that the spring is completely disengaged from the hook on the drum before you separate them.

CARRIAGE AND RAILS

The function of the carriage is to support the paper and to carry it to the left and to the right for typing. The carriage consists of two sections, an outer carriage and an inner carriage. The inner carriage supports the platen and feed rolls and is mounted on the outer carriage in a manner which enables a typist to move it from front-to-rear positions by means of the multiple-copy control lever. This arrangement provides RING AND CYLINDER control for the operator. By positioning the copy control lever toward the rear, the operator can get ring and cylinder control best for the number of copies of paper in the machine (originally adjusted for one sheet).

The inner carriage (fig. 4-19) consists of right and left platen guide plates connected by the platen guide shaft, feed roll release cam shaft, and carriage tie rod. Notches in the rear of the platen guide plates fit on grooved studs riveted to the outer carriage. The left guide plate has an extra bearing point on the outer carriage to provide stability for the linespace mechanism mounted on the guide plate. The paper bail pivot shaft and the front scale are also mounted on the inner carriage, which on late model machines is spring-loaded to the rear.

A resilient nylon washer fitted to each platen guide plate eliminates front-to-rear play in the platen mounting, without adjustments. The washers are so fitted that they are compressed when the platen is installed.

When the multiple-copy control lever mounted on the right platen guide plate is operated, it rotates the platen guide shaft and its eccentric collars. The shaft rotates with the collars; but because it is off center in the collars, it also moves front and rear. This shaft movement causes the entire inner carriage to move forward or backward.

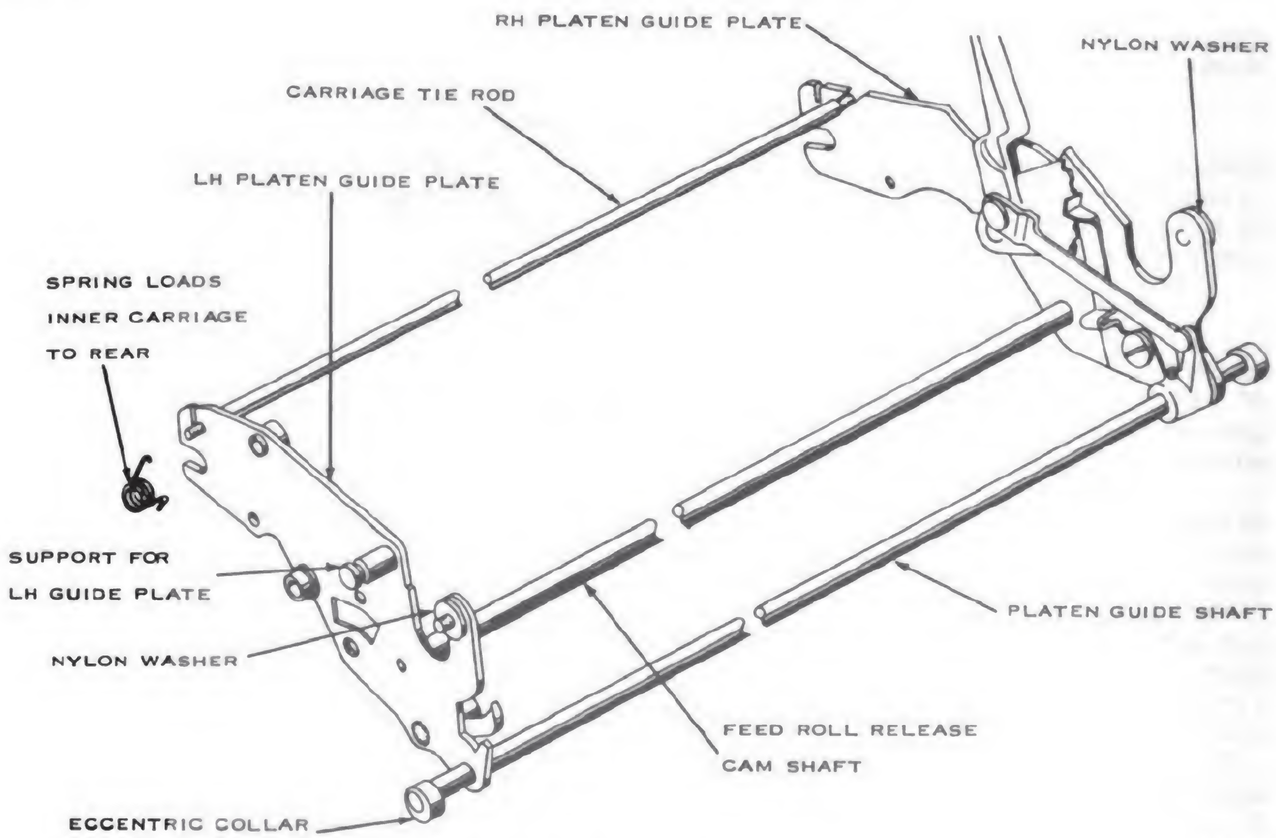

Figure 4-19.—Inner Carriage. 91.21X

The outer carriage consists of a welded box-type carriage bed with an endplate welded to each end. See figure 4-20. The outer carriage mounts (in addition to the inner carriage) the escapement rack, margin rack, and the tab rack. The entire assembly rolls on steel rollers between V-shaped rails, as shown in figure 4-21.

Plastic trucks are used to hold the rollers in uniform spacing. Each truck has four rollers which extend through openings in the truck, as illustrated. The positions of these trucks are maintained by star wheels pinned to the trucks. These wheels engage teeth cut into the upper plate of the carriage bed and the lower edge of the rails. Carriage movement rotates the star wheels between the upper and lower rows of teeth, and the star wheels move the truck assemblies with the carriage. In order for a star wheel to mesh equally with the teeth of the carriage and the rail, it must ride slightly high in the truck. For this reason, the star wheel pin is positioned in the truck slightly above center. Proper installation of trucks is most essential, and is indicated by the downward facing of the flat of the lug on one end of the truck. A 13" carriage is supported by 4 truck and roller assemblies. Longer carriages require more assemblies: 6 for 17" carriages, 8 for 20" carriages, 10 for 24" carriages, and 12 for 30" carriages. Be sure to follow the manufacturer's instructions in the technical manual for the machine when you install trucks.

A lug which extends upward from the margin control lever (fig. 4-20) contacts the left-hand carriage endplate and limits travel of the carriage to the right; and a step on the margin re-set lever contacts the right-hand carriage endplate to limit carriage travel to the left.

When a typist depresses the left or right carriage release button, the carriage release lever pushes a carriage U-bar (fig. 4-20) toward the rear of the machine, allowing it to contact a lug on the pawl release lever. The pawl release lever is mounted on the rear rail by a screw and an eccentric collar, which allows it to pivot. Study figure 4-22. As this lever is pivoted to the rear, it pulls the escapement pawl from the rack to release the carriage.

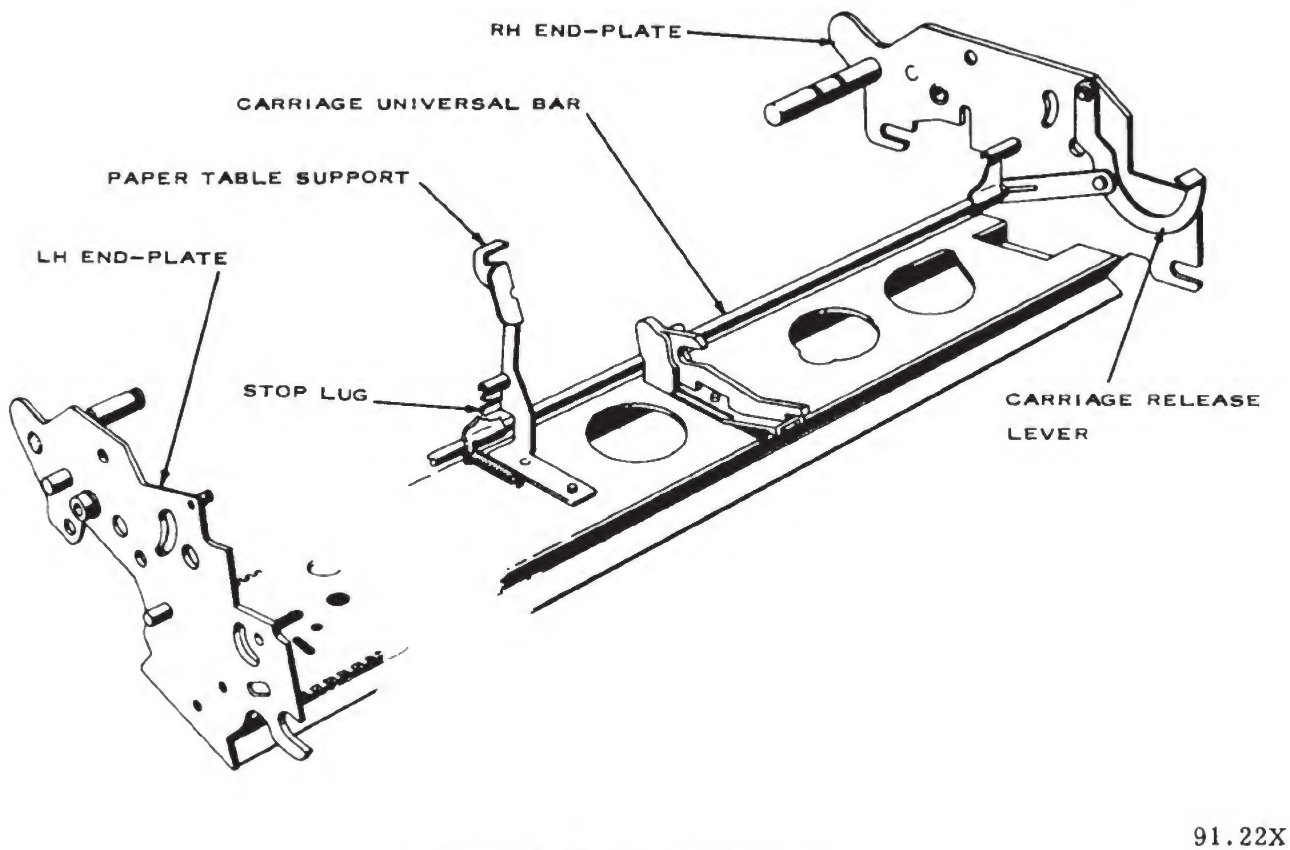

Figure 4-20.—Outer Carriage.

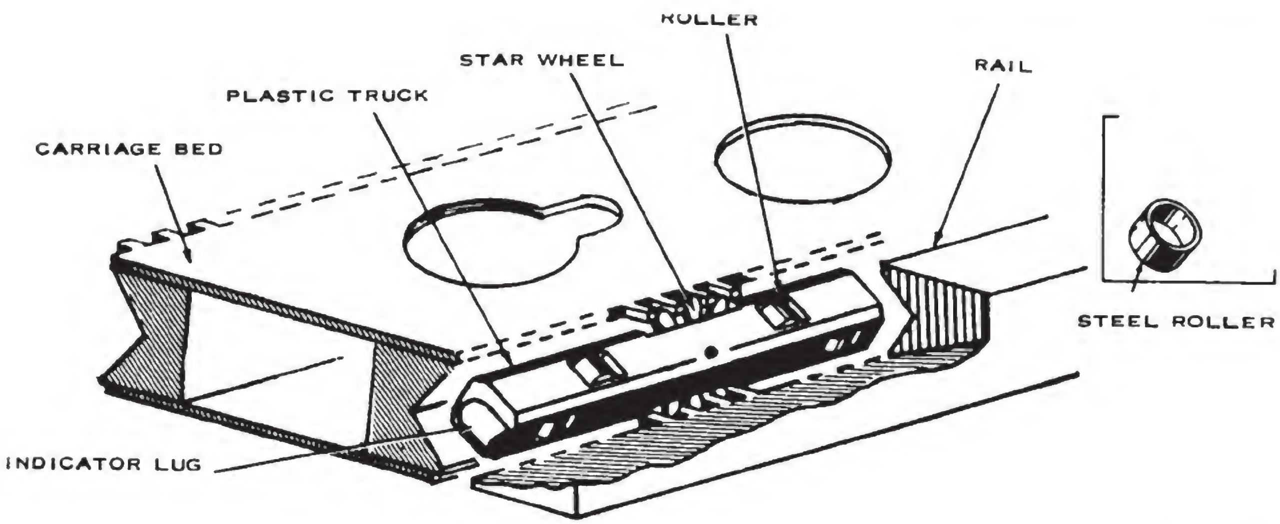

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Figure 4-21.—Carriage Truck and Rollers.

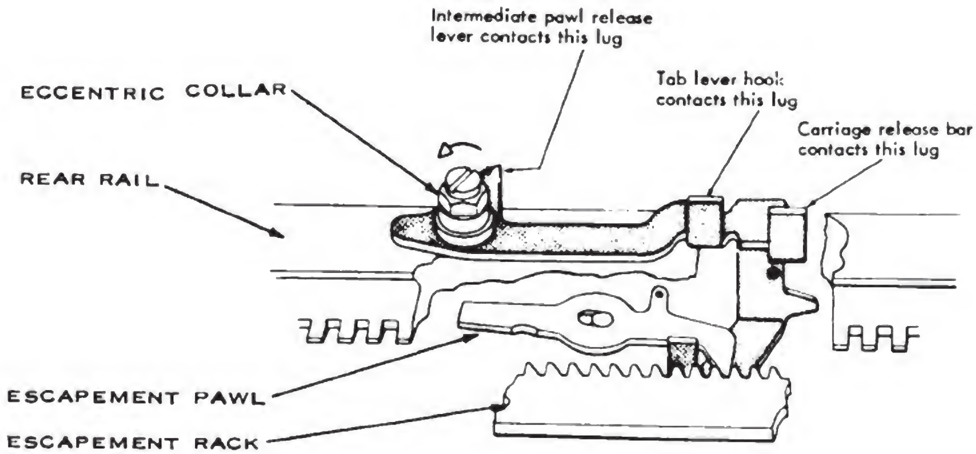

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Figure 4-22.—Pawl Release Lever.

On 13" carriages, a bracket at the middle supports the carriage U-bar and provides an additional pivot mounting for it (fig. 4-20). The bracket extends upward to support the paper table, and it also has a stop lug to limit rearward movement of the U-bar. A similar support is used on longer carriages, which also bridge over the margin rack to support the margin and tab racks.

The platen is mounted on the outer carriage. Its shaft bushings rest on a flat surface of the outer carriage endplates, and latches close over the top of the bushings. Adjustments to eliminate vertical play of the platen bushings can be made by positioning eccentrics in the latch mountings. When the copy-control lever is operated, the platen bushings slide back and forth between the parallel surfaces of the latch and carriage endplates.

PAPER FEED MECHANISM

The function of the paper feed mechanism is to position the paper on successive writing lines. The paper is held against the platen by the pressure of rubber feed rolls, and it rotates with the platen. Study the paper feed mechanism illustrated in figure 4-23. Pay close attention

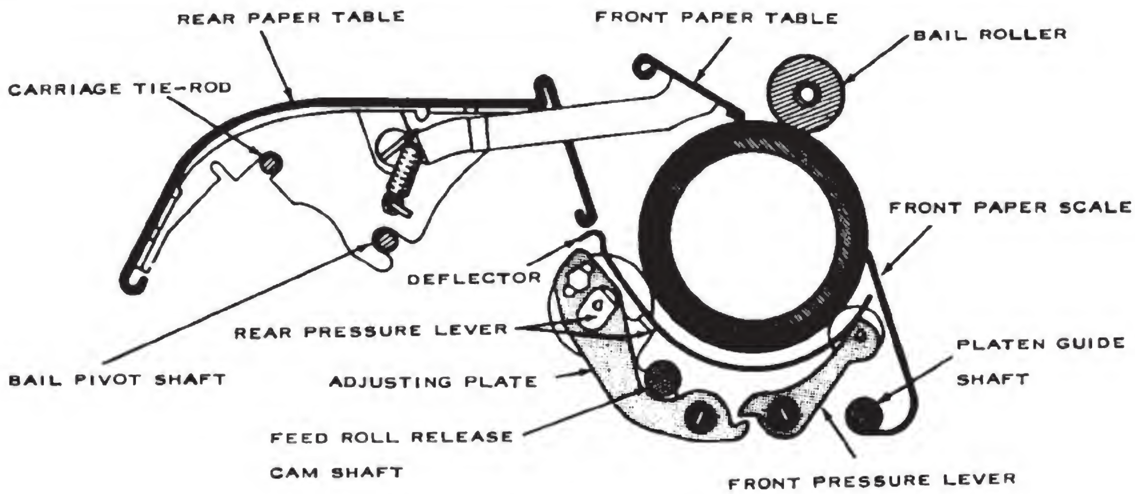

Figure 4-23.—Paper Feed Mechanism. 91.25X

to the nomenclature. You know from previous study how the paper feed mechanism of a standard typewriter functions, so check for similarities and differences in the operation of this feed mechanism.

Paper Feed Rolls

Paper feed rolls (fig. 4-24) are assembled in sets with four feed rolls in each set—two front feed rolls and two rear feed rolls. The number of sets used in a carriage is dependent upon its length. Spacing of sets is controlled by feed roll center supports between them. These supports (fig. 4-25) are mounted at intervals along the carriage bed for these reasons: (1) to provide support beneath the cradles, (2) to prevent bowing of the paper feed mechanism in the middle, and (3) to provide bearing surface for additional multiple-copy control eccentrics mounted along the platen guide shaft.

Feed rolls are molded on a hub which turns on the feed roll shaft. Two hubs are positioned on each shaft by spring retainer clips, as shown in the illustration. Note the feed roll cradles, pressure levers, and the C clips fitted to the ends of the plastic bushings to hold the pressure levers and cradles together.

Feed Roll Release Action

Study figure 4-26 to learn how the feed roll release mechanism works. Note in part A of this illustration the position of the feed roll release cam shaft when the feed rolls are holding the paper against the platen. To release the holding action of these feed rolls, the typist must pull the feed roll release lever forward to cause the feed release cam shaft to rotate and lower all the feed rolls simultaneously. This cam shaft extends the full length of the inner carriage and passes through each cradle assembly. Each rear pressure lever rests in a camming slot of the cam shaft (part A, fig. 4-26). The deep part of the slot allows the rear pressure lever to enter the slot far enough for the feed rolls to contact the platen. When the shaft is rotated (part B, fig. 4-26), the pressure levers are forced farther out of the slot and the rear feed rolls are forced away from the platen. An adjusting plate is secured to the rear pressure lever and moves with it.

MARGIN RESET MECHANISM

The word MARGIN means the amount of space between typed material (end of line, etc.) and the edge of the paper. Margin stops on a typewriter margin rack can be set at various positions to determine the amount of left-to-right movement of the carriage, which determines the widths of the margins.

The operator of a typewriter can relocate margins to any desired point by:

1. Positioning the carriage at its present margin.
2. Depressing the margin reset button (fig. 4-27) and holding it down.

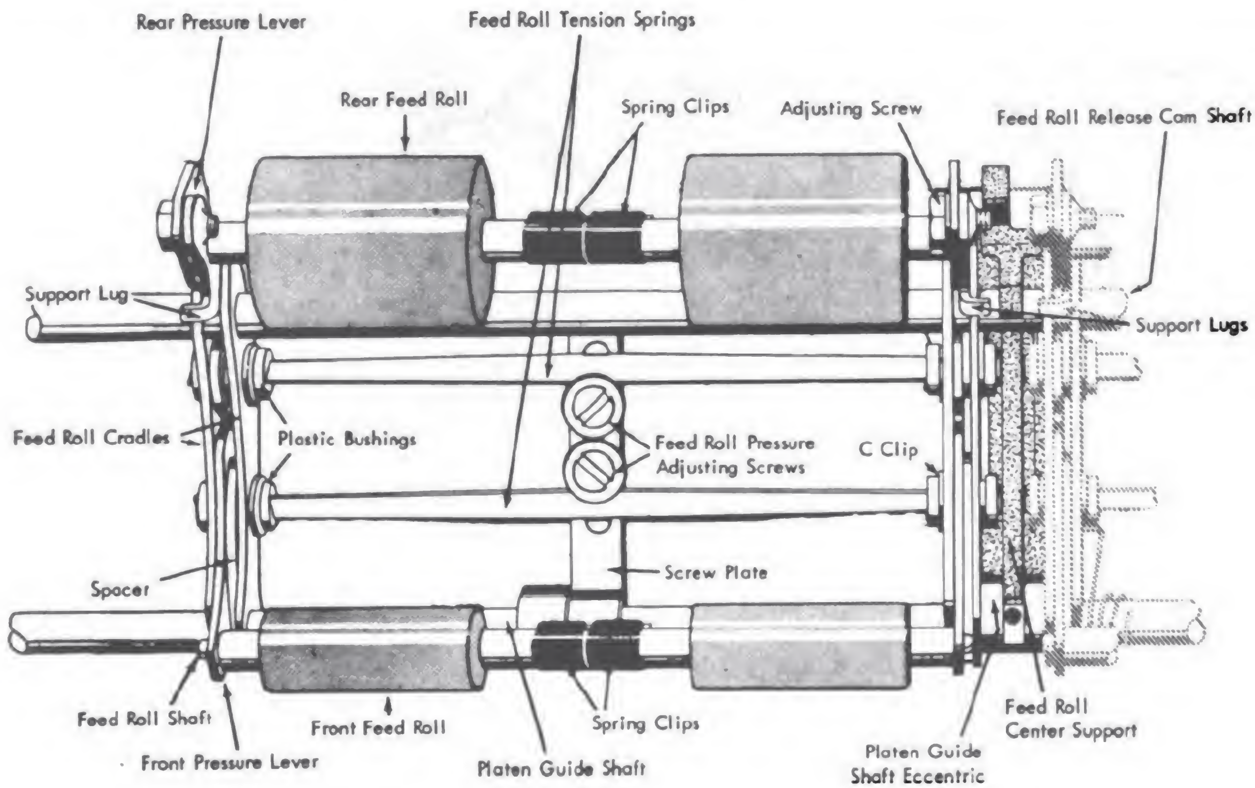

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Figure 4-24.—Paper Feed Rolls.

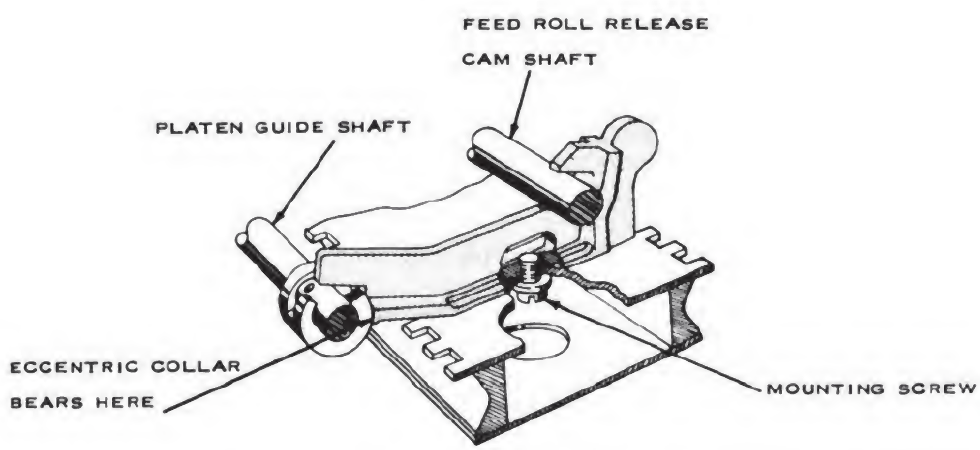

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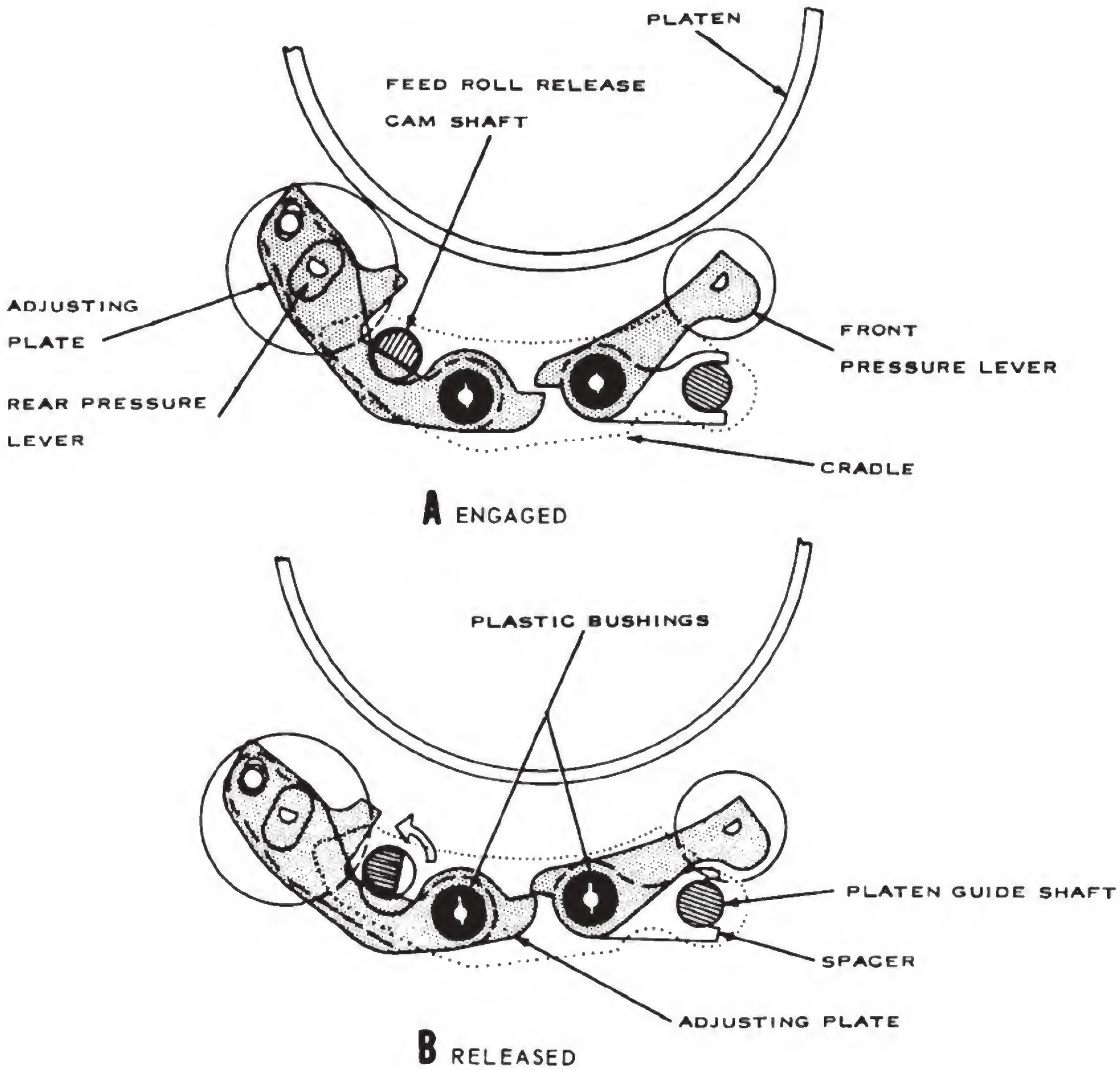
Figure 4-25.—Feed Roll Center Support.

3. Moving the carriage to the desired location.

4. Releasing the margin reset button.

Study figure 4-27 carefully, noting particularly detail A and B, pivot stud for the reset lever, and the mounting stud and fulcrum. When the margin re-set button is depressed, the keylever pivots on its mounting stud and (through linkage) rotates the pin on the left end of the



91.28X

Figure 4-26.—Feed Roll Release Action.

margin re-set lever downward. This pin contacts the slider and removes the slider pin from the margin rack teeth, allowing free movement of the carriage to the desired position.

MARGIN RELEASE MECHANISM

The margin release mechanism enables an operator to position the carriage beyond the margins without changing the margin stop settings. This mechanism is shown in figure 4-28. Observe the position of the carriage at the LH margin stop, and then note the position of this stop when the operator types through it.

When the margin release keylever button is depressed, the keylever pivots on its fulcrum and raises the tab actuating lever. The tab actuating lever then pivots the tab lever and lowers its right end, which lowers the margin control lever mounted to it, allowing the margin stop to pass over the margin control lever.

LINELOCK MECHANISM

The linelock mechanism serves two purposes: (1) to lock the keyboard when the carriage comes to the end of the line (RH margin), and (2) to lock the keyboard when the switch is turned off.

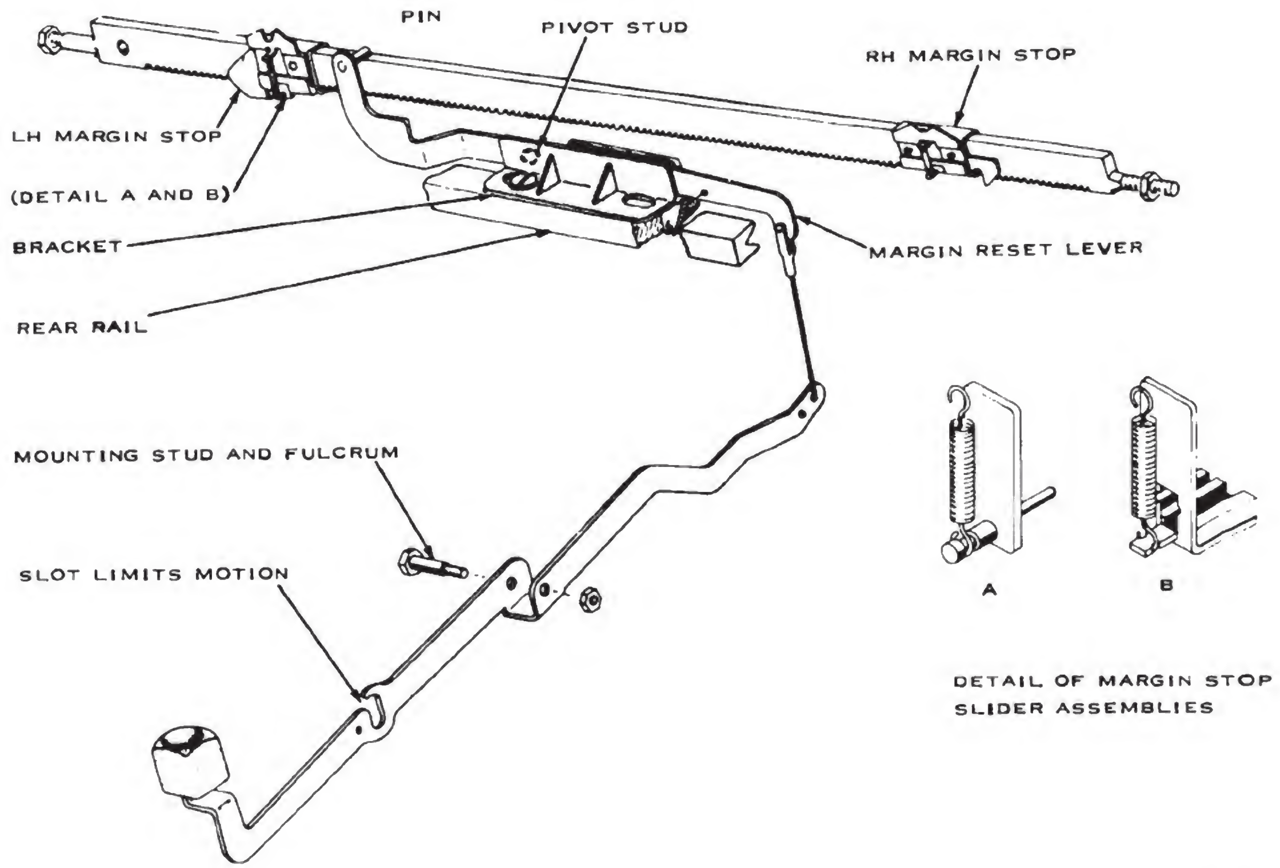


Figure 4-27.—Margin Reset Mechanism. 91.29X

The locking bar (fig. 4-29) is located beneath the keylevers, which are recessed just above the area contacted by the locking bar, leaving a projecting lug at the bottom. Study the illustration. The locking bar is mounted on a fulcrum wire which extends through the right and left side frames, and it can be pivoted on this wire to block operation of the keylevers. The wire and bar slide to the left and also to the right, as well as pivot forward and backward. The wire is spring-loaded to the right and to the rear. A bushing on the right end of the wire contacts a camming surface on the side of the switch lever, which provides the right-to-left action of the locking bar.

A push rod (illustrated) on the left side of the locking bar connects with linkage on the rear rail and transfers carriage movement from the margin control lever to pivot the locking bar when the carriage reaches the RH margin. The switch lever also pivots the locking bar when it is rotated to the OFF position. Study the illustration carefully. Note the carriage return lock.

A separate section of the locking bar locks ONLY the carriage return keylever. It pivots independently on the fulcrum wire and allows operation of the carriage return mechanism to return the carriage from the RH margin. The carriage return keylever is locked only when the switch is off. A lug on the carriage return lock extends through the right side frame, in which position the switch lever contacts it.

Motion of the carriage pivots the linelock lever, mounted to a stud on the tab lever mounting bracket. A wire link connects the lower end of the linelock lever to a bellcrank mounted on the rail brace support. The bellcrank is connected to the linelock push rod, which extends to a point just behind a lug on the left end of the linelock bar.

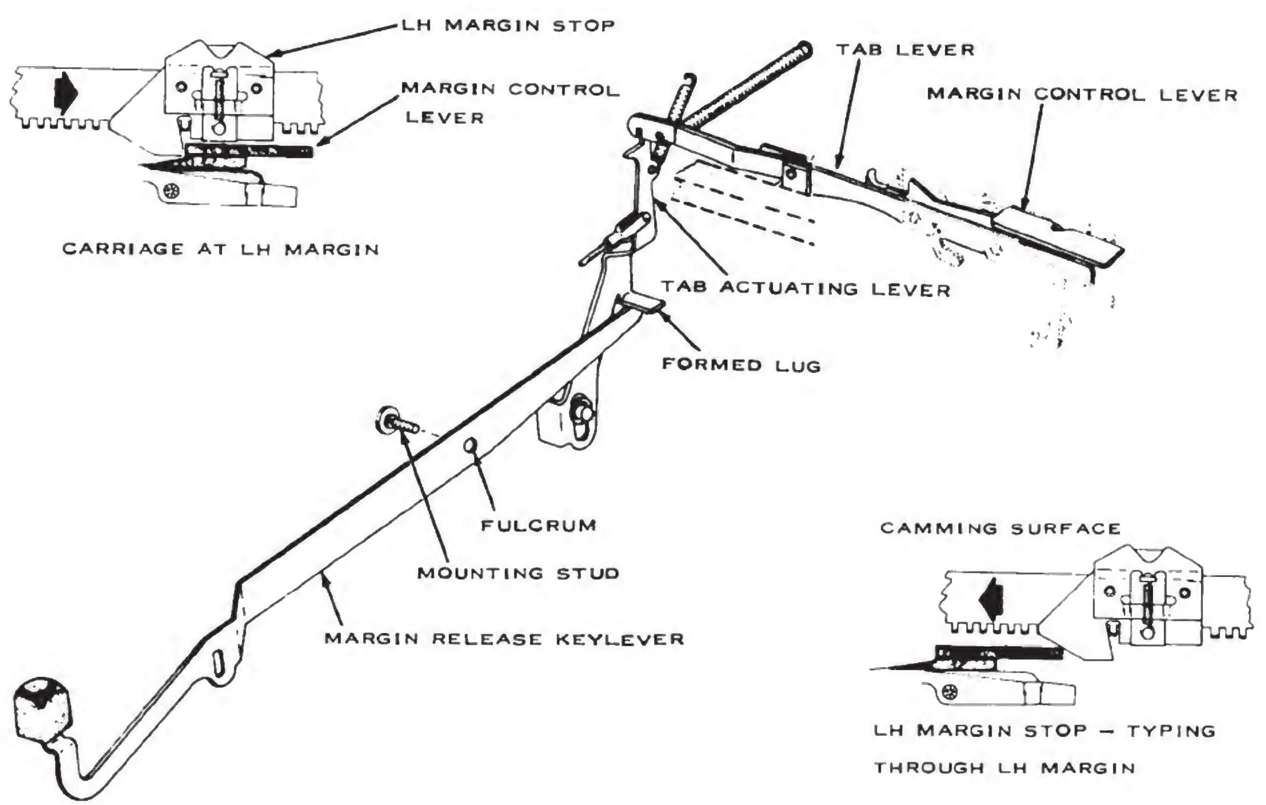


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Figure 4-28.—Margin Release Mechanism.

As the carriage reaches the RH margin, the RH margin stop moves the margin control lever to the left. (Note elongated holes in this lever.) This movement rotates the linelock lever and, through linkage, pushes the push rod toward the front of the machine, where the rod contacts the lug on the linelock bar and rotates the bar under the keylevers to prevent further keylever operation. As the carriage is moved away from the RH margin, spring action on the linelock lever and the restoring spring of the locking bar restore the linelock push rod to the rear of the machine.

When the switch is turned off, its camming surface forces the linelock bar to the left. This action positions a locking lug in line with the backspace and spacebar keylevers. The switch motion also pivots the carriage return lock forward against the linelock bar, and this motion pivots the linelock bar forward under the keylevers. When the switch is off, all keys except the shift key and the spacebar are locked.

FUNCTIONAL CAMS

The spacebar, carriage return, tab, backspace, shift, and ribbon feed constitute the service mechanisms of a typewriter. The motion required to operate these mechanisms in an electric typewriter is obtained through metal FUNCTIONAL CAMS. Some of these cams have single lobes and some have double lobes. Cams with single lobes rotate 360° for each operation, to provide a great amount of motion to the mechanism. Double-lobed cams, on the other hand, provide less motion but faster action by rotating only 180° for each position.

Double-lobed cams (fig. 4-30) located on the left side of the machine are used to operate the spacebar, tab, and ribbon feed mechanisms. Single-lobed cams (fig. 4-31) located on the right side of the machine are used for the carriage return and backspace mechanisms. The shift cam, illustrated in figure 4-32, on the right side, is a special double-lobed cam which is also double acting.

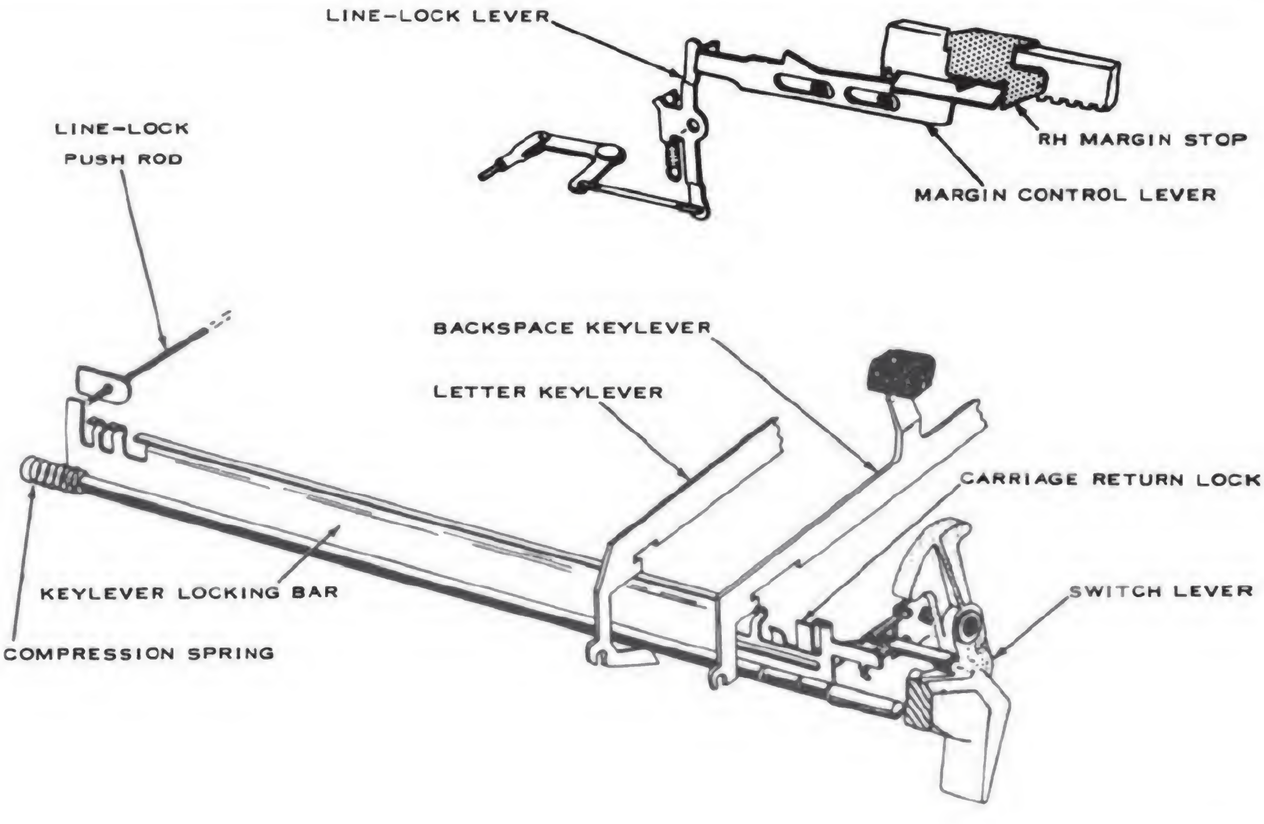

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Figure 4-29.—Linelock Mechanism.

All functional cams but the ribbon cam are mounted on short fulcrum rods at either side of the cam lever bearing support. The LF fulcrum rod has a C clip fitted over a groove in the rod. This clip is positioned in an opening of the cam bearing support casting and prevents the fulcrum rod from working out of the support (fig. 4-7). The RH fulcrum rod is held in position in the cam bearing support by a retainer on the right side frame which fits into a groove at the end of the rod. The ribbon cam is mounted on a separate pivot stud screwed into left side frame.

Adjustable stops position each cam in its rest position, to maintain a clearance between the low point of the cam and the power roll.

Protrusions on both sides of a cam help to activate and control it. A spring finger, for example, bears against a protrusion on one side of a cam to rotate it into the power roll when the cam is released. See figure 4-33. A lug (part of the body) extends out from the other side of the cam (fig. 4-34) as a control point for the cam release lever to engage and hold the cam from the power roll, or release it into the power roll for operation.

A cam release link (fig. 4-30) from the keylever pivots the cam release lever on the cam frame. The release lever has two lugs slightly offset from each other (fig. 4-34), one slightly behind the other and farther out from the center of the cam. The forward lug is called the primary lug; the other one is the non-repeat lug. The release lever primary lug holds the cam lug when all parts are at rest. A depressed keylever pivots the release lever toward the center of the cam (opposite for ribbon cam release lever) and releases the cam into the power roll. After the cam rotates over its high point, with the keylever depressed, the non-repeat lug catches the cam lug. As the key-lever is released, the non-repeat lug pivots away from the cam and releases the cam lug to the primary lug of the release lever. This action re-sets the cam and it is then ready for another operation.

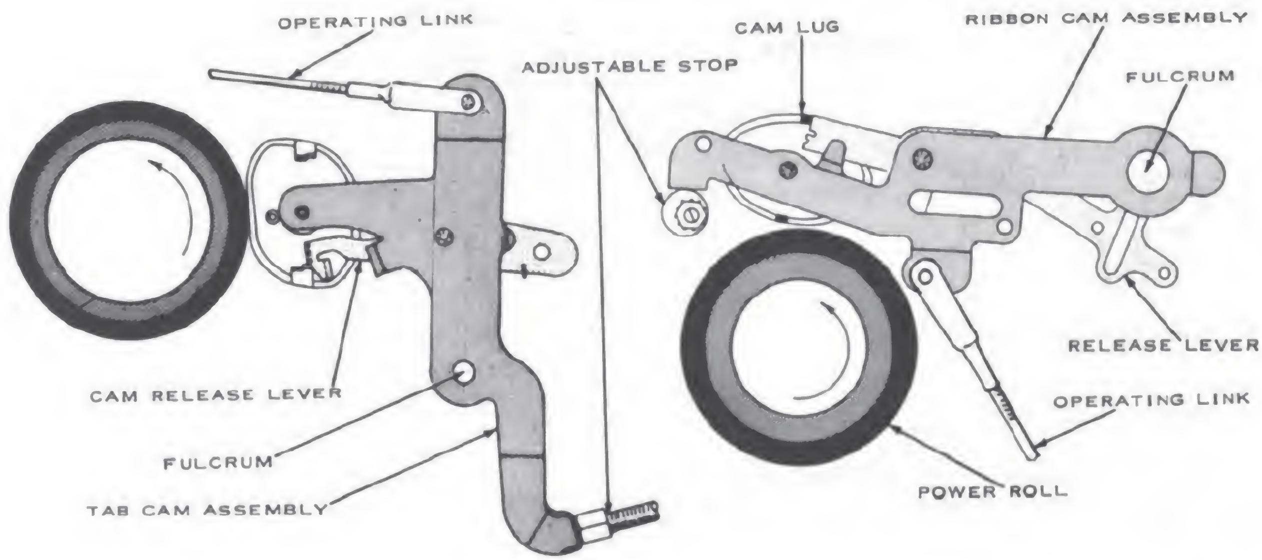

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Figure 4-30.—Double-lobed Cams.

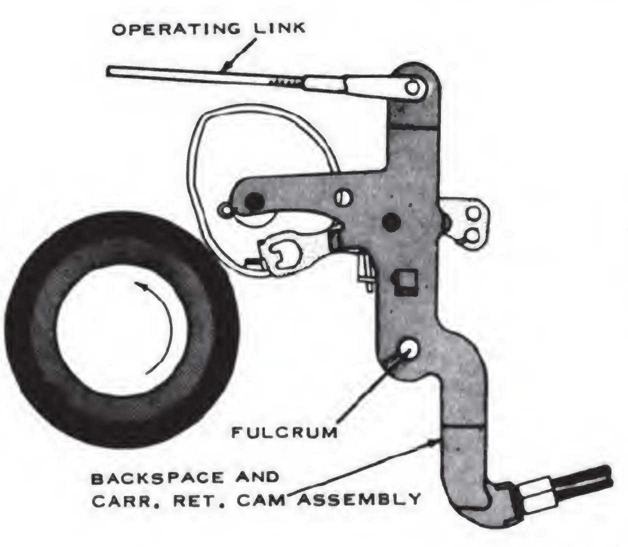

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Figure 4-31.—Single-lobed Cam.

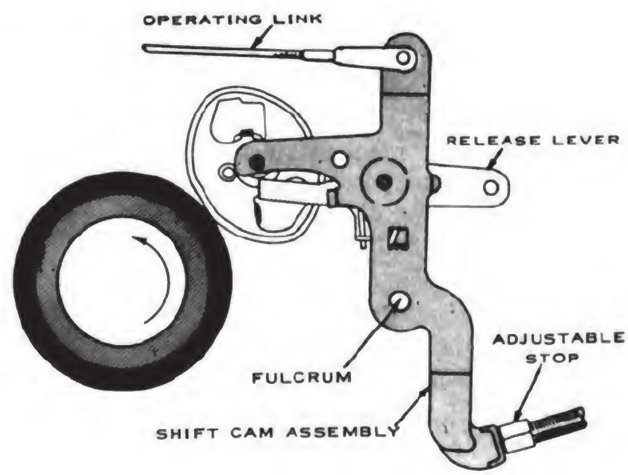

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Figure 4-32.—Double-lobed Shift Cam.

A repeat feature is provided by a different type of cam release lever which pivots the non-repeat lug of the release lever farther toward the center of the cam and out of the path of the lug on the cam.

Because of special requirements of the shift mechanism, the shift cam is constructed differently from other double-lobed cams. See figure 4-35. This cam rotates 1/2 revolution when the keylever is depressed and completes the revolution when the keylever is released.

The shift cam release lever has only one lug. The shift cam has two lugs at 180° but one is closer to the center than the other (fig. 4-35). Hence, when the release lever releases the other lug, the release lever moves into the path of the inner lug to stop the cam at 1/2 revolution. When the release lever releases the inner lug, it moves into the path of the outer lug to stop it at the completion of the revolution.

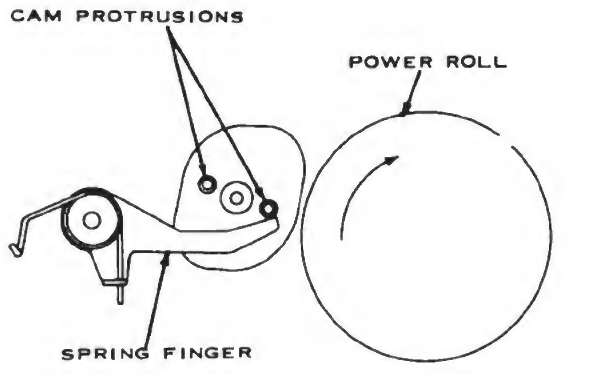

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Figure 4-33.—Cam Spring Finger.

As the cam rotates over its high point, it causes the cam to pivot on its fulcrum. An operating link attached to the cam frame delivers the motion to the service mechanism involved. The operating linkage is restored to the rest position by a spring attached to some part in the linkage. This spring also loads the cam into the power roll to ensure that it rotates with the power roll.

SPACEBAR MECHANISM

The spacebar mechanism enables an operator to trip the escapement without printing. The spacebar has controlled repeat operation. Study figure 4-36. Note magnified portion (circle) of one end of the bar.

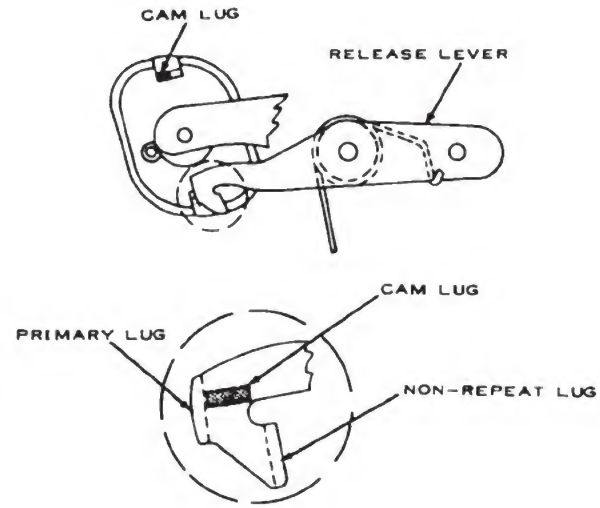

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Figure 4-34.—Cam Release Lever (Non-repeating).

The spacebar is mounted on brackets on the spacebar shaft with nylon pins and barbed retainer clips. The bar has a stem which extends down from its center through a guide to keep it upright on the mounting. The bottom of the spacebar stem also contacts an adjustable flat spring which provides restoring tension for the spacebar and shaft assembly. A rubber stop on the front frame engages the lower hooked portion of the stem and determines the upper (rest)

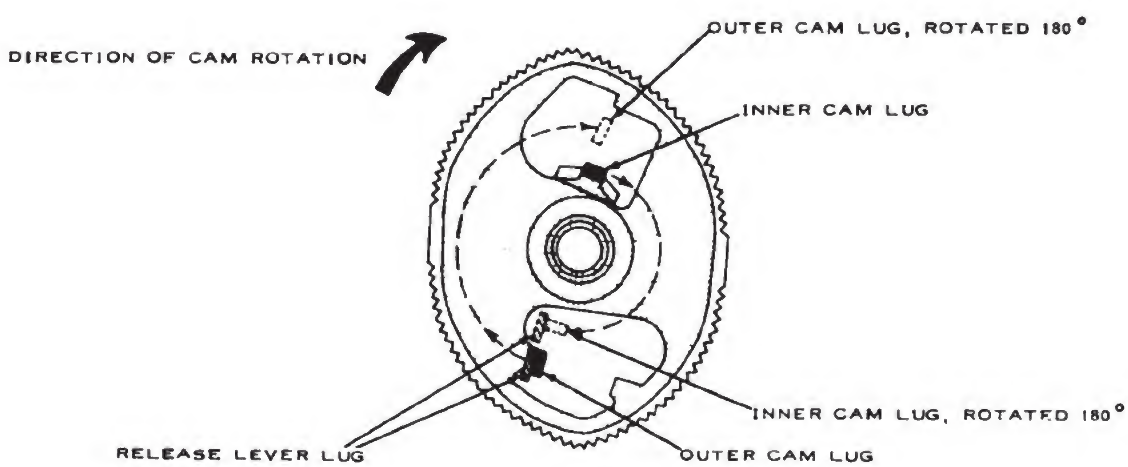

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Figure 4-35.—Shift Cam.

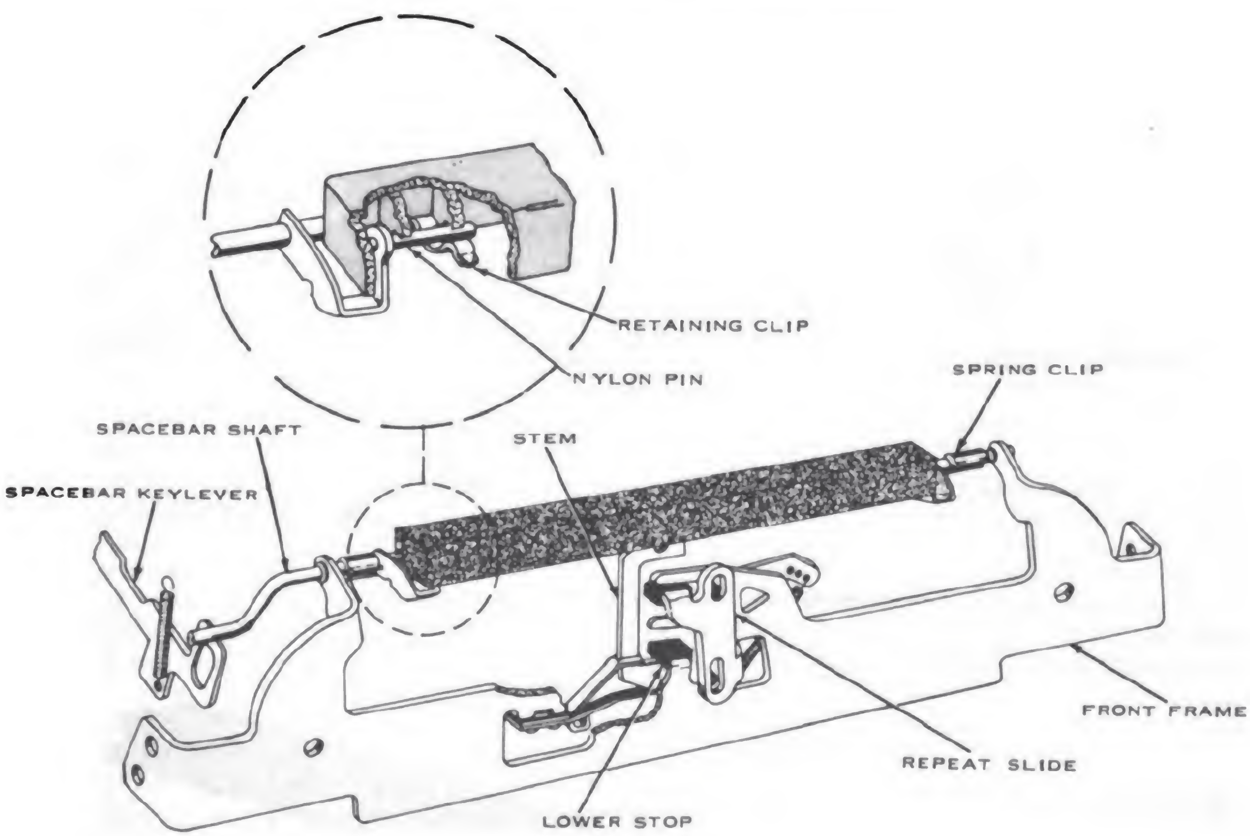

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Figure 4-36.—Spacebar and Repeat Slide Stop.

position of the spacebar. The downward movement of the spacebar is limited to a single space operation by another rubber stop which contacts the upper portion of the spacebar stem. This stop is mounted on the repeat slide, held in the UP position by a spring. Additional pressure must be applied in order to depress the slide stop against the spring pressure for repeat spacebar operation.

When depressed, the spacebar mechanism pivots the spacebar shaft mounted on the front frame. The shaft depresses the keylever on the left side of the machine (fig. 4-37), which moves the cam release link down and pivots the cam release lever to release the spacebar cam lobe into the power roll. Note fulcrum point of the cam. As the cam lobe rotates, the cam frame pivots toward the front of the machine, pulling with it an operating link secured to its top and to the bottom of the escapement lever plate (fig. 4-37). Forward movement of the operating link rotates the escapement lever plate and the escapement lever shaft to which it is mounted. The escapement lever shaft extends through the power frame and has an escapement lever attached to its right end. Rotation of this shaft causes the escapement lever to contact the escapement trip lever, causing it to pivot about its mounting on the left rail brace and push the escapement pawl spacer forward into contact with the escapement pawl tail. This action trips the escapement pawl from the rack as the cam reaches its high point. A spring on the escapement lever plate restores the linkage and cam to the rest position.

A typist can obtain repeat action by depressing the spacebar beyond the normal depth for single space operation. Depth for single spacing is determined by contact of the stem with the spring-loaded rubber stop on the repeat slide (fig. 4-38). Additional pressure is required to overcome spring tension which holds the repeat slide up. Spring tension is adjustable to suit individual touch. Depression of the spacebar and

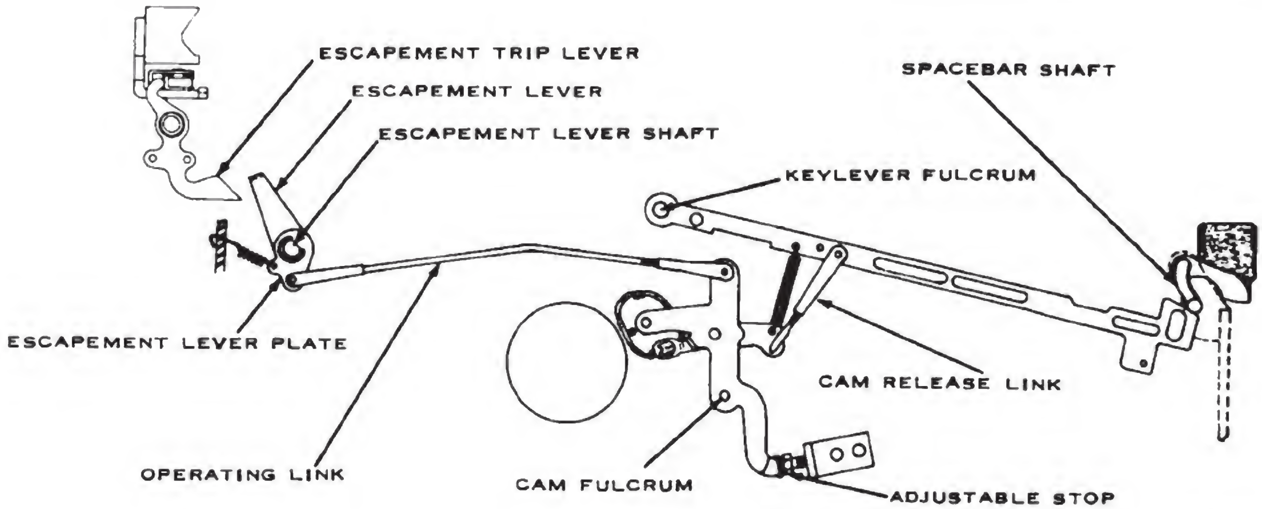

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Figure 4-37.—Spacebar Mechanism.

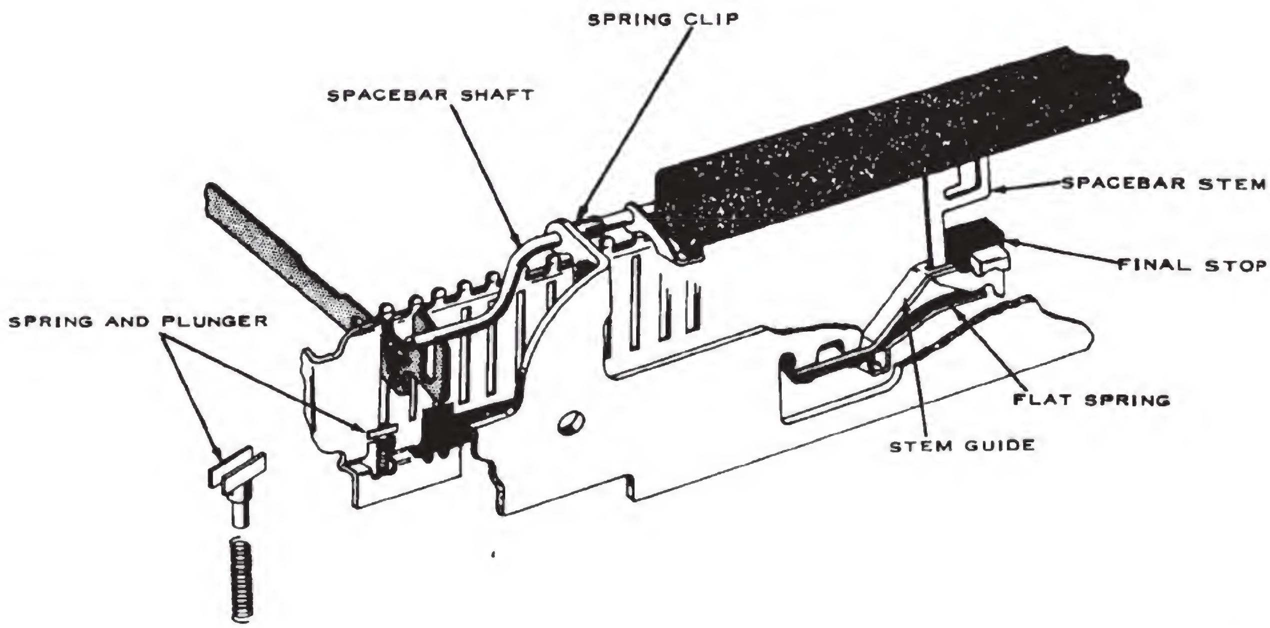

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Figure 4-38.—Spacebar, Spring and Plunger.

the repeat slide causes the cam release lever to pivot out of the path of the cam lug, allowing the cam to rotate continuously and trip the escapement every time it rotates over its high point (until spacebar is released). (Some C-1 typewriters use a spring-loaded plunger in the keylever guide comb to control repeat operation.)

DECELERATOR AND CENTRIFUGAL GOVERNOR

Deceleration is the absorption of carriage movement energy over a timed interval. On the C-1 machine, the decelerator and centrifugal

governor absorb 85 percent of the shock of carriage landing on tab and carriage return. On tabulation, the time interval is determined by the tab check lever movement. On carriage return, the time interval is determined by the margin control lever movement.

The deceleration mechanism transfers the energy of carriage movement to the centrifugal governor. Study this mechanism in figure 4-39 (centrifugal governor attached). It has three spring clutches which individually drive the decelerator gear, which drives the centrifugal governor.

The centrifugal governor is part of the decelerator mechanism and controls the mainspring to limit the speed of the carriage during tabulation. The decelerator also operates the governor as a brake to ease carriage landings on tabulation and during carriage return. The principle of operation of the centrifugal governor is: AN ACTION WHICH ROTATES THE GOVERNOR PRODUCES A REACTION FROM THE GOVERNOR WHICH RESISTS ROTATION. This reaction is produced in the manner explained in the following paragraphs. Study illustration 4-40 as you read the discussion.

The governor has two arms mounted on a disc rotated by a shaft and gear. A pinion gear on the shaft meshes with the large decelerator gear (fig. 4-40). The arms are mounted on pivots and are held toward the center of the governor by a spring which connects one arm to the other. As the shaft rotates at increasing speed, centrifugal force develops and causes the arms to pivot outward, overcoming spring tension. This action forces the oiled, felt brake shoes on the arms against the plastic governor housing. Friction developed between the brake shoes and the housing slows down the speed of revolution until the centrifugal force is diminished. When the centrifugal force becomes less than the tension of the spring between the arms, the spring pulls the arms away from the housing. Then, without hindrance from friction, the speed

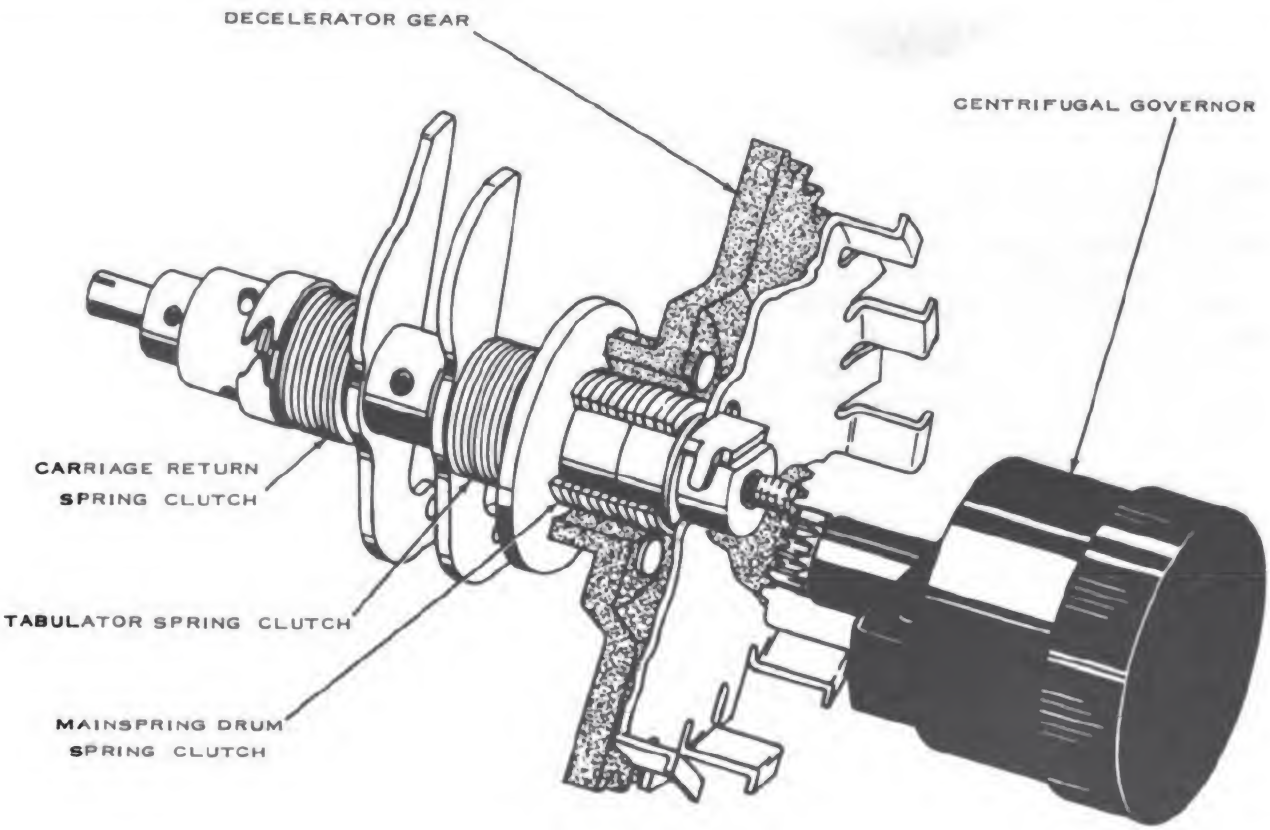

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Figure 4-39.—Decelerator and Centrifugal Governor.

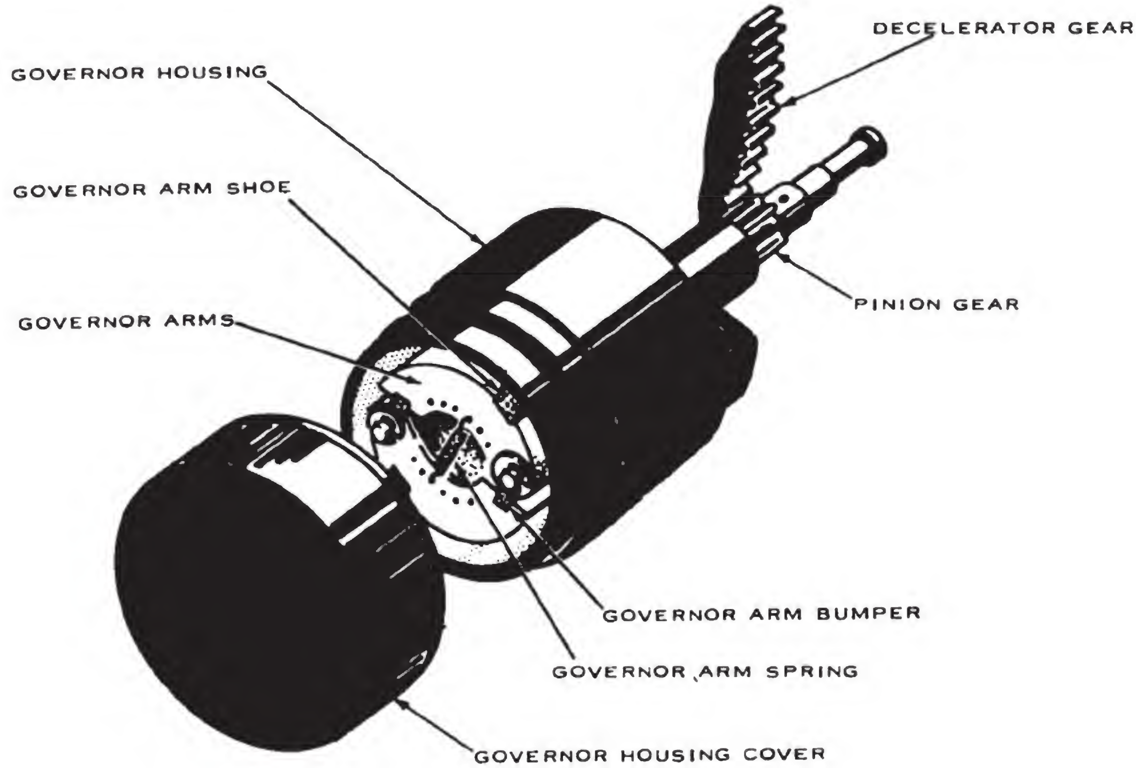

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Figure 4-40.—Centrifugal Governor Mechanism.

of the governor can again increase until centrifugal force overcomes spring tension and drives the brake shoes against the housing.

The centrifugal governor does not react until a certain SPEED is attained; and for this reason uniform speed of the carriage from right to left positions (regardless of the difference in carriage tension as the mainspring unwinds) is always maintained. Carriage speed on tabulation is adjusted to equal the speed of carriage return.

Force of the center spring determines how fast the governor rotates before it acts to reduce the speed of rotation. Effective force of this spring can be controlled by the position at which it is attached to the arms. (Note holes.) If the spring is attached farther away from the pivot points of the arms, its effective force is increased; and the governor must then be rotated at a higher speed to develop enough centrifugal force to overcome the spring force.

Tab Deceleration

Carriage movement left or right causes rotation of the mainspring drum. Mainspring tension provides carriage movement to the left for tabulation. The mainspring rotates the drum, which winds the carriage tension tape and pulls the carriage. This direction of drum rotation causes the mainspring clutch to drive and rotate the decelerator gear and the centrifugal governor. In this manner, power of the mainspring is controlled to limit carriage speed during tabulation.

Carriage movement to the right opens the spring clutch and causes it to slip. Movement in this direction also pulls tension tape off the drum and rotates the drum against the force of the mainspring. During normal typing, the mainspring drum (rotated by mainspring tension) moves the carriage to the left, the same direction as during tabulation. The mainspring drum clutch transfers this rotation to the decelerator gear assembly and causes the centrifugal governor to turn; but the speed of carriage movement during normal typing does not rotate the centrifugal governor fast enough to cause the governor arms to contact the housing.

Motion to operate the tab decelerator comes from the tab check lever, shown in figure 4-41.

When the tab mechanism is operated, the tab check lever moves to the right to meet the tab

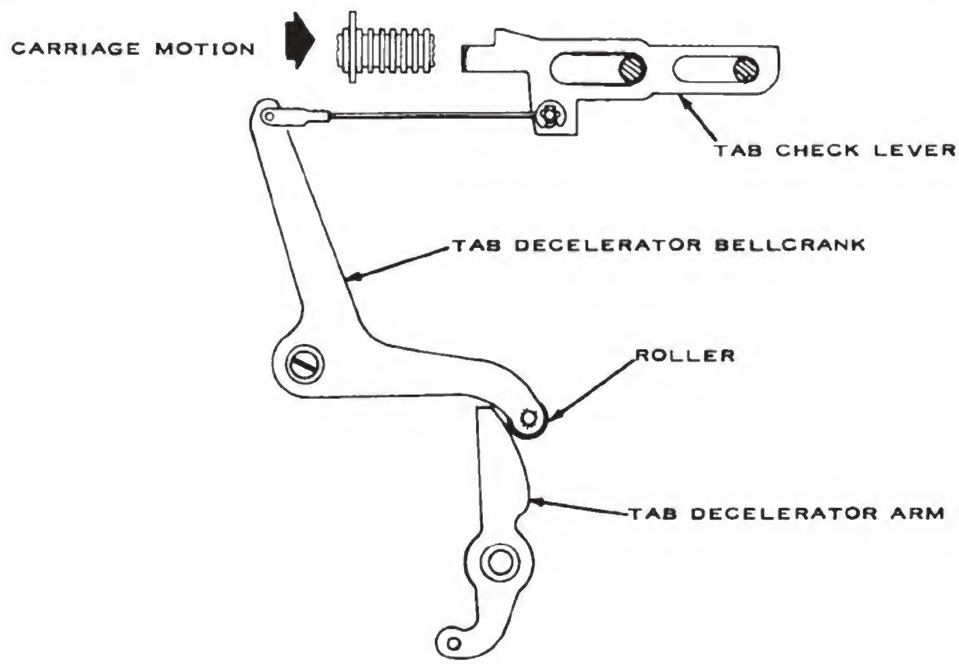

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Figure 4-41.—Tab Deceleration (Rear View).

set stop on the carriage. As the tab stop contacts the check lever and pushes it back (elongated holes), it operates the decelerator. A link from the check lever connects to a bellcrank which has a roller on the end of its other arm. This roller is in contact with the tab decelerator arm, and it rides down the cam surface of the tab decelerator arm when the tab check lever is in motion. Movement of the tab decelerator arm by the roller causes the spring clutch to drive the decelerator gear and centrifugal governor. Reaction by the governor causes the decelerator arm to resist rotation, and this resistance is transmitted back through the bellcrank and check lever. As the check lever offers increasing resistance to the tab stop on the carriage, the speed of carriage travel is decelerated.

Carriage Return Deceleration

Motion to operate the carriage return decelerator comes from the margin control lever. As the carriage approaches the left margin, the margin stop contacts the margin control lever and pushes it to the right. This action is transferred through the margin control bellcrank (fig. 4-42) to the carriage return decelerator bellcrank. Study figure 4-42 carefully.

The roller on the decelerator bellcrank is in contact with the carriage return decelerator arm, and motion from the margin control lever causes the roller to ride down the cam surface of the decelerator arm and rotate the arm about the decelerator shaft. Rotation of the decelerator arm causes the carriage return spring clutch to drive the decelerator gear and centrifugal governor. The governor reacts to resist the force acting upon it, and this resistance is transmitted back to the margin control lever, causing it to resist the margin stop on the carriage and decelerate the speed of carriage travel.

The stress created during carriage return deceleration is much greater than stress produced during tabulation. Carriage return deceleration starts the centrifugal governor rotating from a stationary condition, so the inertia to be overcome is much greater than during tabulation, when the governor is already rotating before deceleration begins.

The amount of tabulation obtained on carriage return and tabulation depends upon three factors:

1. Position of the center spring attachment on the centrifugal governor arms. When the spring is moved closer to the pivot point, the decelerator operates sooner and with greater force exerted by the brake shoes.

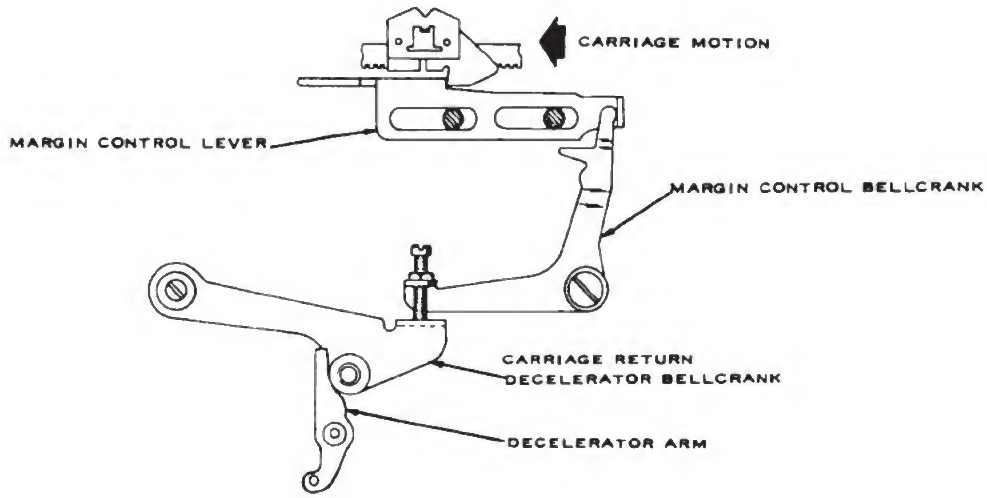

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Figure 4-42.—Carriage Return Deceleration (Rear View).

2. The curve in the camming surface of the decelerator arms. The curve affects the rate of change in the centrifugal governor speed, and it is so designed to provide a uniform rate of deceleration during the operation.

3. The section of the decelerator arm on which the bellcrank roller works. The distance of the roller from the pivot point of the decelerator arm affects the amount of angular rotation the decelerator arm receives. The same amount of motion from the roller rotates the arm farther and faster if it is applied closer to the pivot point of the arm. This is the adjustment point.

TABULATOR MECHANISM

The tab mechanism enables the operator of the machine to put typing in accurate, orderly columns by rapidly moving the carriage to preset positions. Study the tabulator mechanism illustrated in figure 4-43. Follow all the levers and links from the tab keylever around to the centrifugal governor.

When the operator depresses the tab keylever, a connecting link activates the tab cam, which starts the movement of all links and levers to release the escapement pawl from the escapement rack to allow rapid movement of the carriage. When the carriage reaches the desired position, the carriage is stopped, the tab is unlatched, and the escapement pawl is restored to the rack. The postion of the tab set stop determines where the carriage stops, and in which tooth of the escapement rack the pawl re-enters and holds. Carriage speed is decelerated during its last 1/2 inch of travel to reduce the shock of stopping the carriage.

Tab stops are set by a tab set finger, shown in figure 4-44. Note also the tab clear arm.

The typist may set any stop from a rack of tab stops on the carriage (illustrated). Tab columns can be positioned with a minimum of two spaces between columns. When the TAB CLEAR lever is depressed, it clears the tab stops (all of them at one time if the tab clear button is held depressed during a full-length carriage return). Spring fingers in the rack hold the stops in either the SET or CLEARED position.

The basic part of the tab mechanism is the tab lever assembly, so mounted on a bracket that it can pivot forward and backward, and up and down. There are three parts to this assembly. See figure 4-45. Note the pivot point, where it is fastened by a stud to the mounting bracket. Other parts of the assembly are mounted to this lever, as illustrated. The front side of the tab lever has a hook which pivots the pawl release lever and removes the pawl from the rack when the tab is operated. A projection of the tab lever extends down and toward the rear of the machine. The vertical portion of this projection provides contact surface for the tab latch; the lower portion operates a carriage return tab interlock which allows the tab to supersede carriage return. Two heavy studs riveted to the rear of the

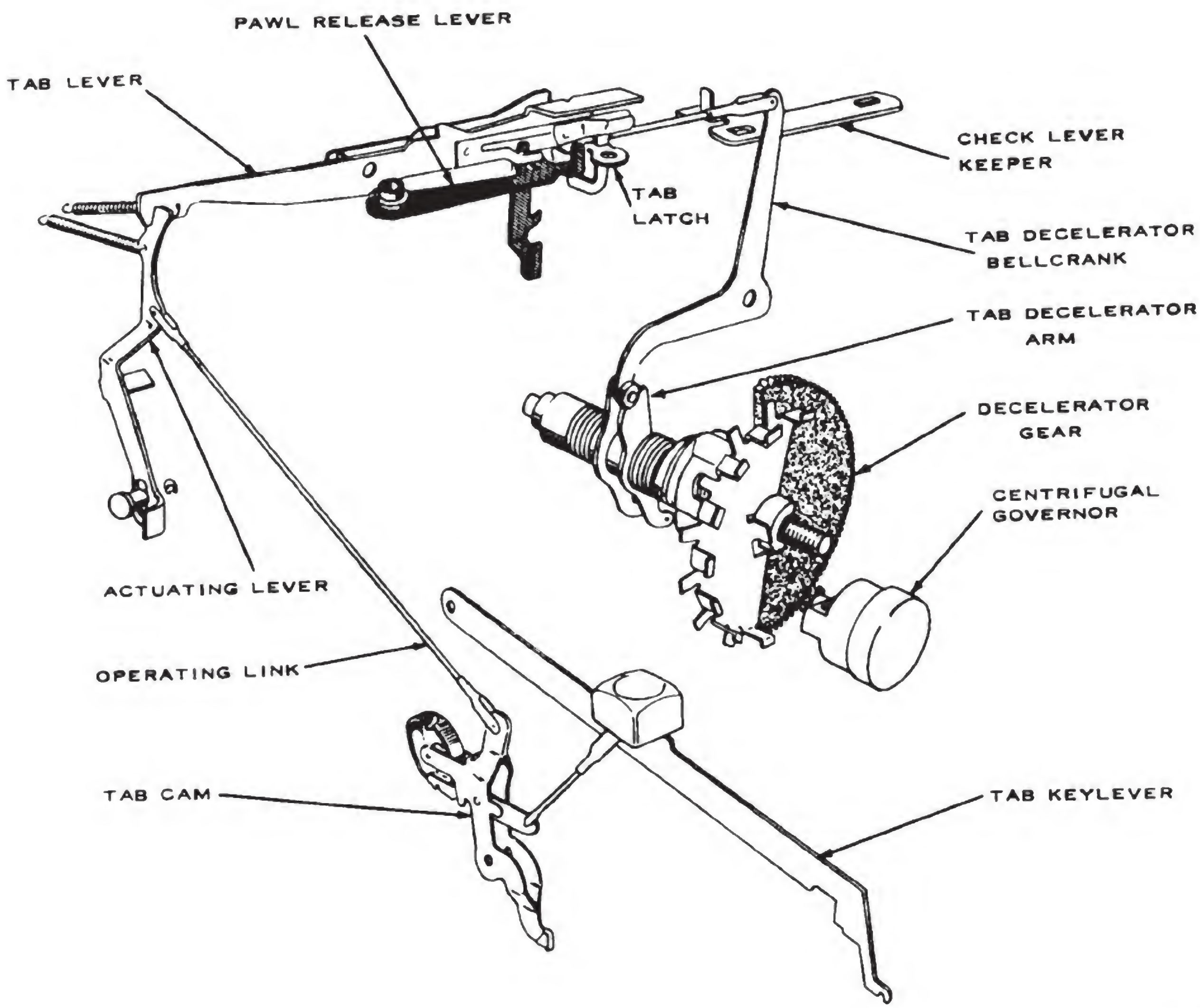

Figure 4-43.—Tabulator Mechanism.

tab lever support the margin control and tab check levers. You already know the function of these levers.

CARRIAGE RETURN MECHANISM

The carriage return mechanism returns the carriage to the left margin and turns the platen ratchet to space the paper. If the carriage is already at the left margin, carriage return is a linespace operation only.

Study the carriage return mechanism illustrated in figure 4-46. The carriage return tape is fastened to the left side of the carriage and passes under the carriage to the right side of the machine, over a pulley, and to the carriage return pulley, to which it is secured. When the pulley is rotated by the carriage return clutch, it winds the tape and pulls the carriage to the right.

A clutch disc is mounted on the end of the power roll shaft, between the clutch pressure plate and the clutch pulley. Operation of the clutch compresses the clutch disc and pulley together and causes them to rotate as a unit to wind the carriage return tape. The speed of the carriage on return is dependent upon the speed of the power roll and the diameter of the clutch pulley.

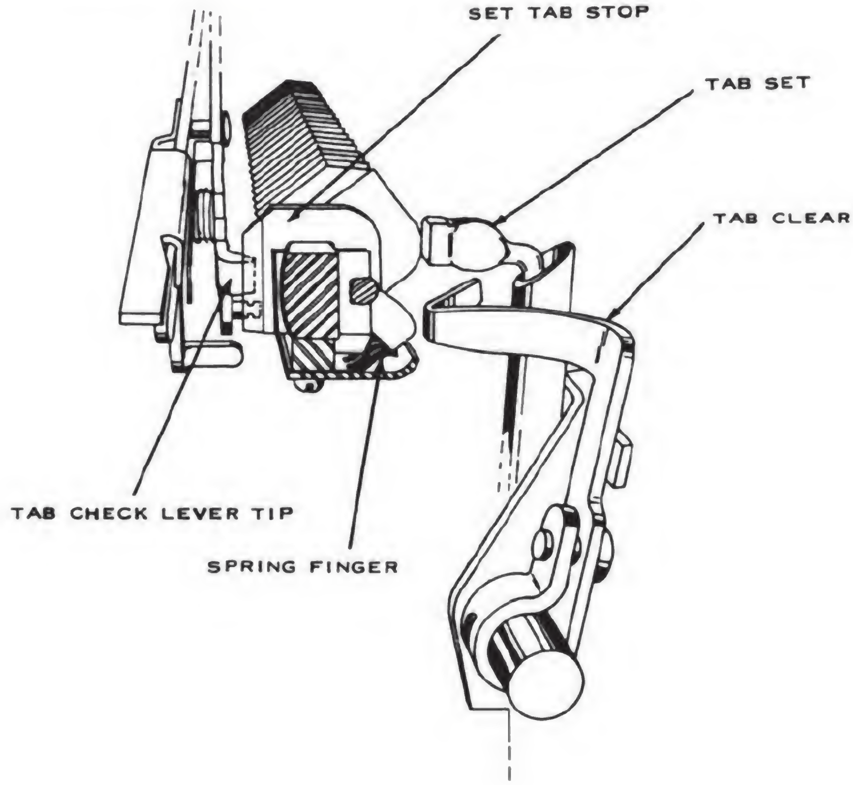

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Figure 4-44.—Tab Set and Tab Clear Levers.

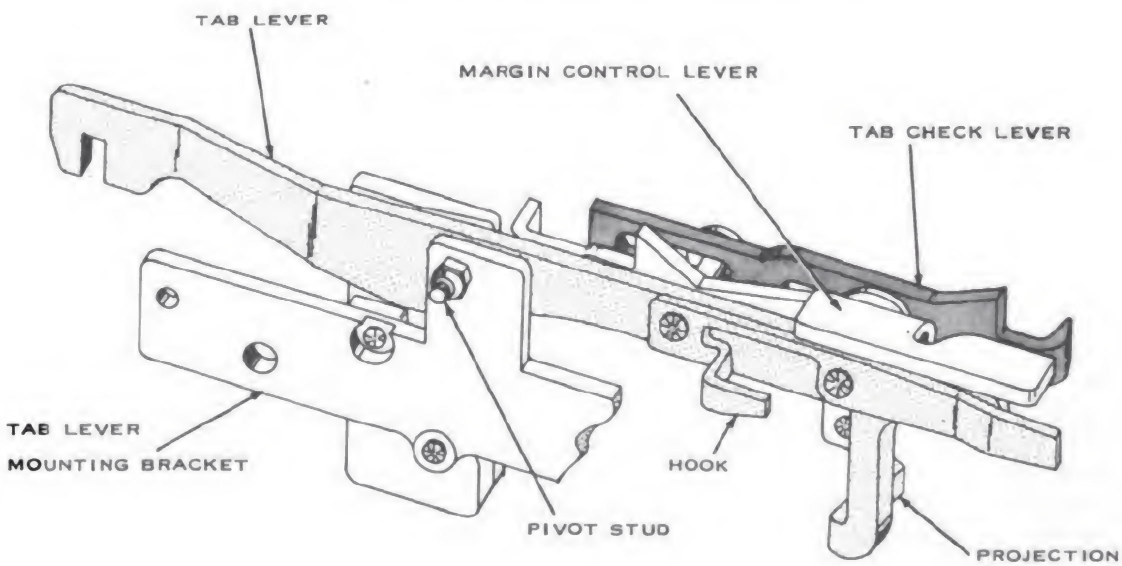

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Figure 4-45.—Tabulator Lever Assembly.

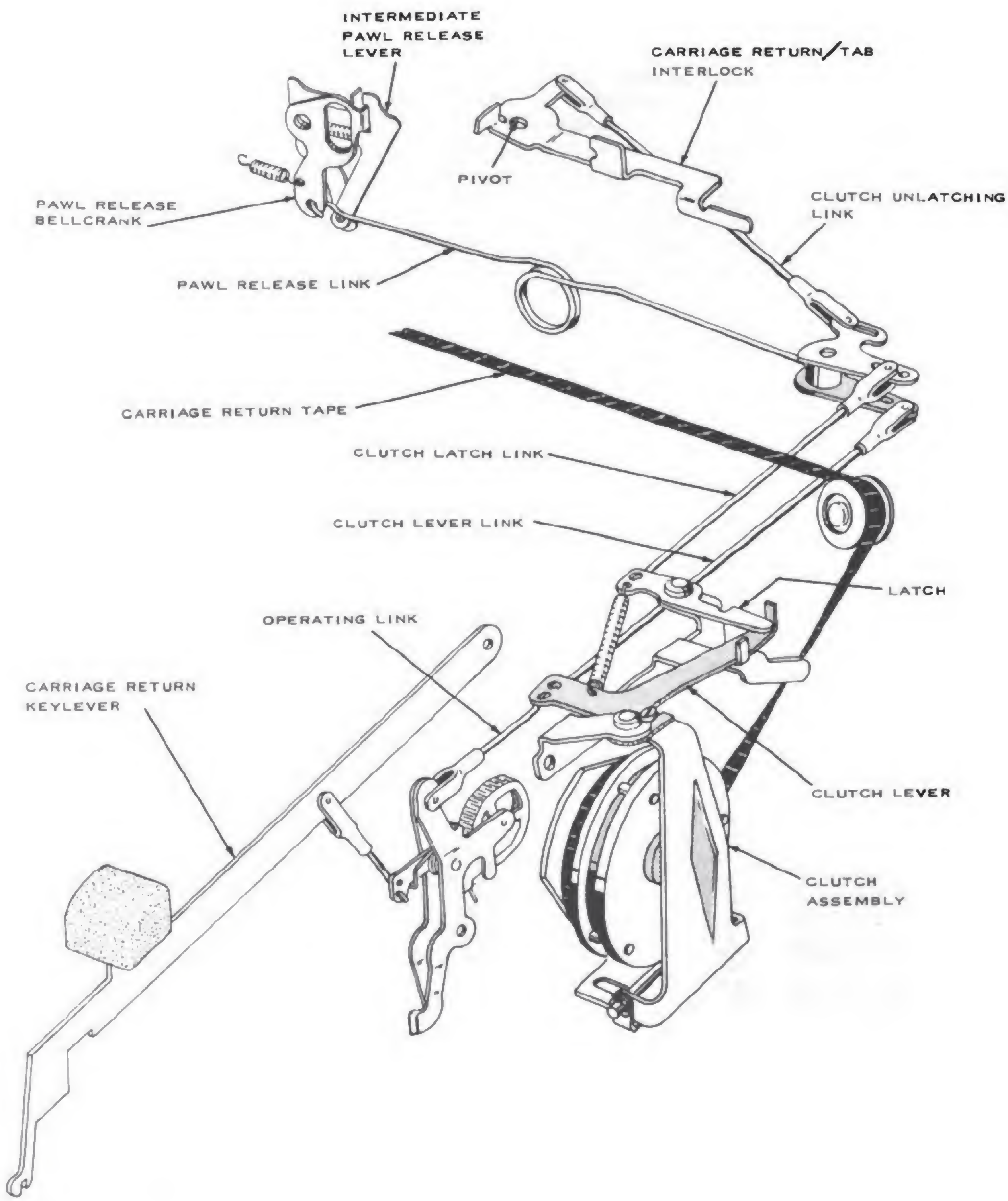

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Figure 4-46.—Carriage Return Mechanism.

When the carriage return keylever button is depressed, it releases a single-lobed cam, which revolves and pulls the clutch lever toward the front of the machine. The clutch lever then pivots to move the clutch operating arm against the clutch plate which, in turn, presses the rotating clutch disc against the clutch pulley. This action causes the pulley and plate to rotate with the disc and wind the carriage return tape. The initial pull on the tape spaces the platen and causes the carriage to return to the right.

As the carriage return cam pulls the clutch lever forward, the clutch latch is moved by spring tension to its latched position. This movement also causes a pull on the clutch latch link and rotates the clutch latch bellcrank, thereby positioning the clutch unlatching link and carriage return/tab interlock (fig. 4-46). The latch holds the clutch compressed until the carriage reaches the LH margin.

The amount of clutch pull on the carriage is controlled by the clutch compression adjustment (fig. 4-47). As illustrated, the lower end of the clutch operating arm is mounted on a pivot shaft, one end of which is spring-loaded to the left by a compression spring. Tension of this spring can be adjusted by a lock nut on the clutch arm retaining bolt. This tension regulates the amount of pressure applied against the friction disc. The clutch must be so adjusted that it will return the carriage from any position, but at the same time allow enough slippage of the disc to hold the carriage against the pull of the clutch without stalling the motor.

To release the escapement pawl from the rack, the clutch lever pulls a rear clutch lever link, which rotates the clutch lever bellcrank and pulls the pawl release link. This pivots the pawl release bellcrank about its mounting stud, which action then lifts the hook-shaped lug on the intermediate pawl release lever. Study figure 4-48. As this assembly moves, it rotates the pawl release lever and releases the escapement pawl from the escapement rack. The pawl release lever also operates the backspace interlock to prevent the backspace pawl from entering the escapement rack during carriage return.

As the carriage approaches the left margin, the left margin stop contacts a margin control lever, mounted through elongated holes to a stud on the tab lever (fig. 4-49). (The elongated holes allow sliding motion to the left and to the

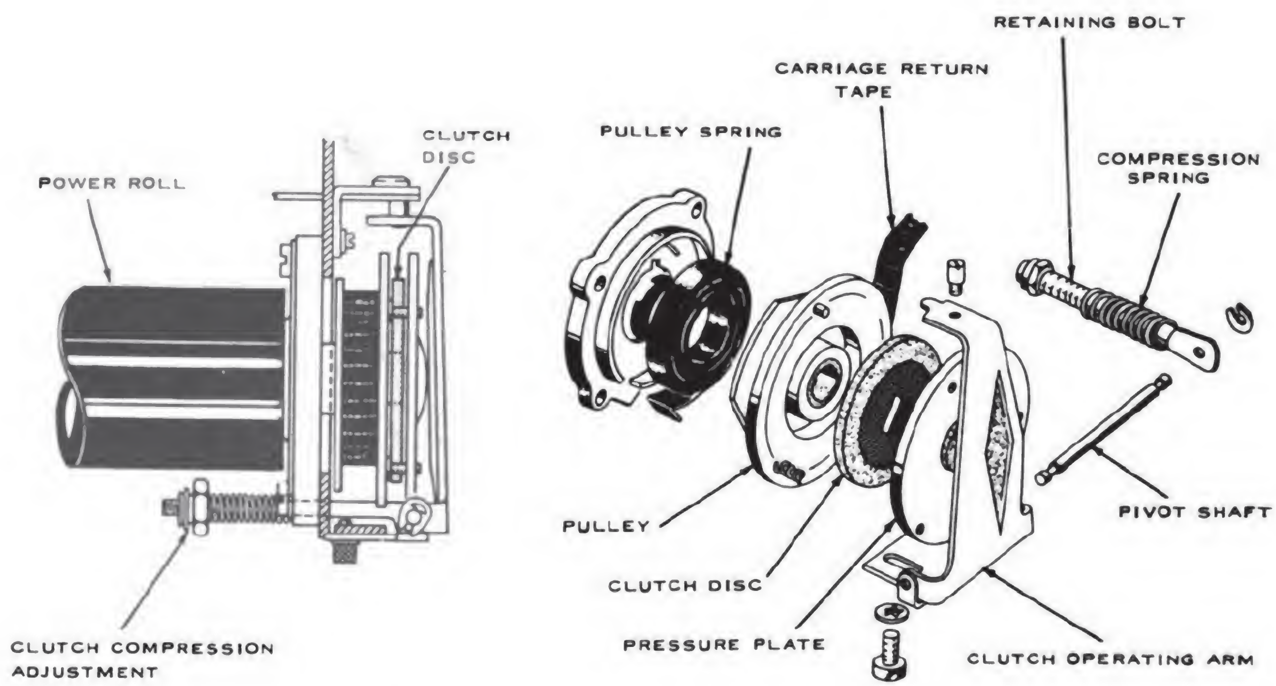

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Figure 4-47.—Carriage Return Clutch.

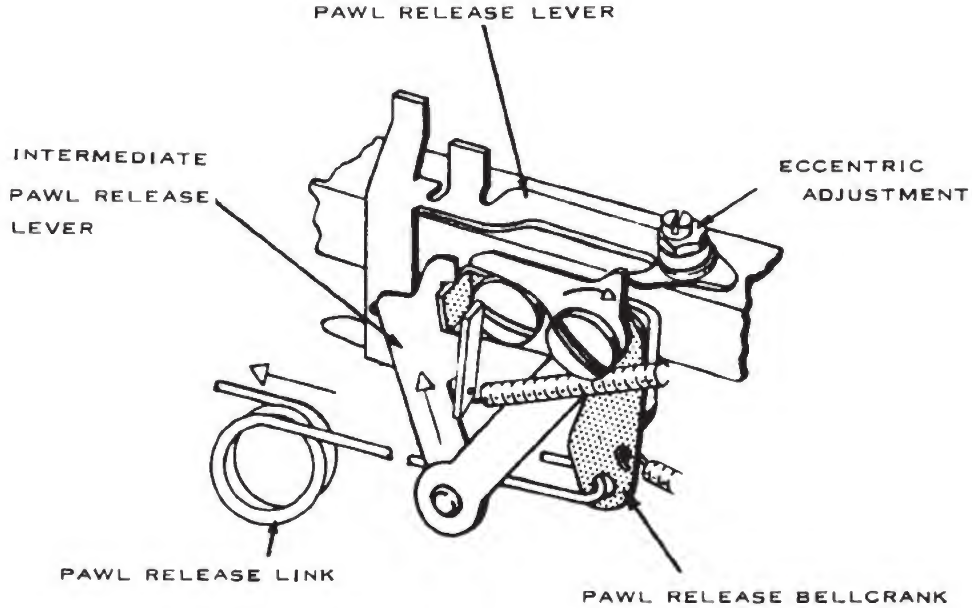

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Figure 4-48.—Pawl Release Mechanism.

right.) The margin control lever is spring-loaded to the left. When the LH margin stop contacts the margin control lever it slides the margin control lever to the right. A lug on the margin control lever pivots the margin control bellcrank. This bellcrank has three functions:

1. It operates the carriage return decelerator bellcrank to decelerate the carriage (fig. 4-49).
2. It pushes the intermediate pawl release lever to disengage it from the pawl release bellcrank. This action allows the pawl release lever to restore to its rest position and the escapement pawl to return to the escapement rack.
3. It rotates the carriage return/tab interlock to unlatch the clutch.

Carriage Overbank

After the carriage reaches the limit of its travel to the right, and all clutch parts are restored to the rest position, the carriage settles back a small distance to the left under mainspring tension. This motion is called OVERBANK. The amount of overbank is the amount of sliding motion in the escapement pawl (.058" or .038") plus the distance that the escapement rack tooth was required to travel beyond the pawl to ensure its dropping safely in front of the tooth (.010" - .015"), as shown in figure 4-50. The amount of this travel is controlled by adjusting the relative position of the margin rack to the escapement rack.

Interlock Operation

During carriage return, the carriage return tab interlock unlatches the clutch, as explained previously; interlocks the action between the carriage and return tab, as shown in figure 4-51; and interlocks carriage return and backspace. If the carriage return and tab are operated together, the tab lever actuates the interlock to unlatch the clutch or to prevent the clutch from latching (fig. 4-51). Tab operation supersedes carriage return. An operator can use this interlock feature to obtain a partial carriage return and tabulation to the nearest set tab stop by touching the tab key just after the carriage return key.

The third function of the carriage return/tab interlock is illustrated in figure 4-52. A flat extension of the right end of the carriage return/tab interlock follows the backspace interlock during carriage return. The backspace interlock

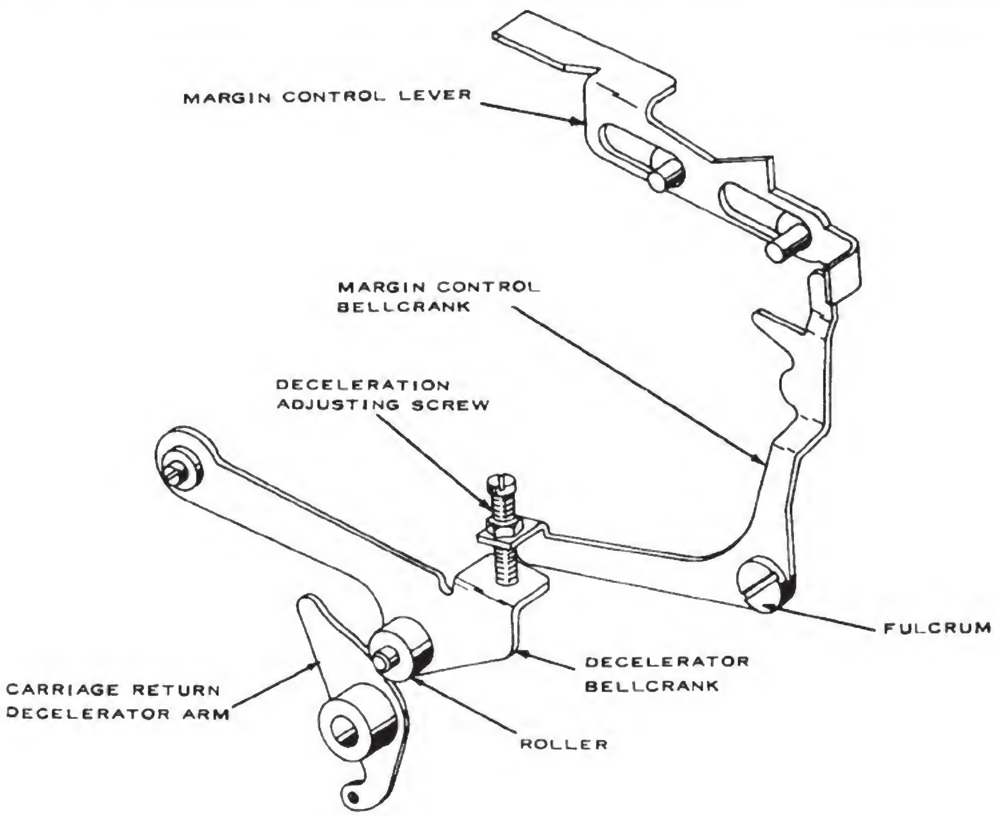

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Figure 4-49.—Decelerator Operation by Margin Control Bellcrank.

must pivot around the backspace pawl and get out of the way of the carriage return/tab interlock to allow the amount of motion necessary for the latch to latch up the carriage return clutch. (Pawl release lever actuates the backspace interlock.)

When the backspace pawl is in the rack, it blocks rotation of the backspace interlock and therefore blocks rotation of the carriage return/tab interlock. This prevents the clutch from latching when carriage return is operated during a backspace operation. Clutch surfaces are brought together momentarily as the carriage return pawl rotates through its cycle and the pull on the tape spaces the platen. Carriage return is prevented because the clutch cannot latch up. This action results in a backspace and a line space. On a simultaneous backspace and carriage return operation, the backspace pawl moves into the escapement rack before the carriage return cam acts to rotate the pawl release lever. Hence, rotation of the backspace interlock and the pawl release lever is blocked.

LINESPACE MECHANISM

Initial pull on the carriage return tape operates the linespace mechanism and indexes the platen (fig. 4-53). The tape pulls the index pawl carrier down against the tension of the spring-loaded index lever. This allows the index pawl to engage a platen ratchet tooth and rotate the platen. When the index pawl carrier is in its upper rest position, the pawl is held clear of the ratchet. As the carrier is pulled down, spring tension on the index pawl engages the pawl to the ratchet. Rotation of the ratchet causes a spring-loaded detent roller to ride over the point of a ratchet tooth. The rotation is stopped by an adjustable lower index pawl stop when the detent roller bottoms again between two ratchet teeth to hold the platen in the new position.

The detent release mechanism is shown in figure 4-54. When the line position re-set lever is pulled forward, it activates a cam which removes the detent roller from the ratchet and permits free rotation of the ratchet and platen.

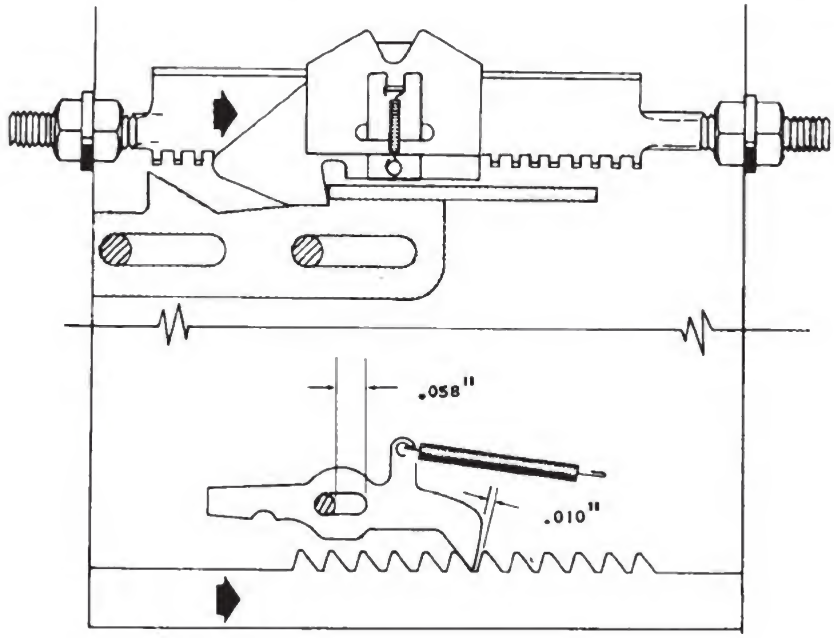

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Figure 4-50.—Carriage Overbank Mechanism.

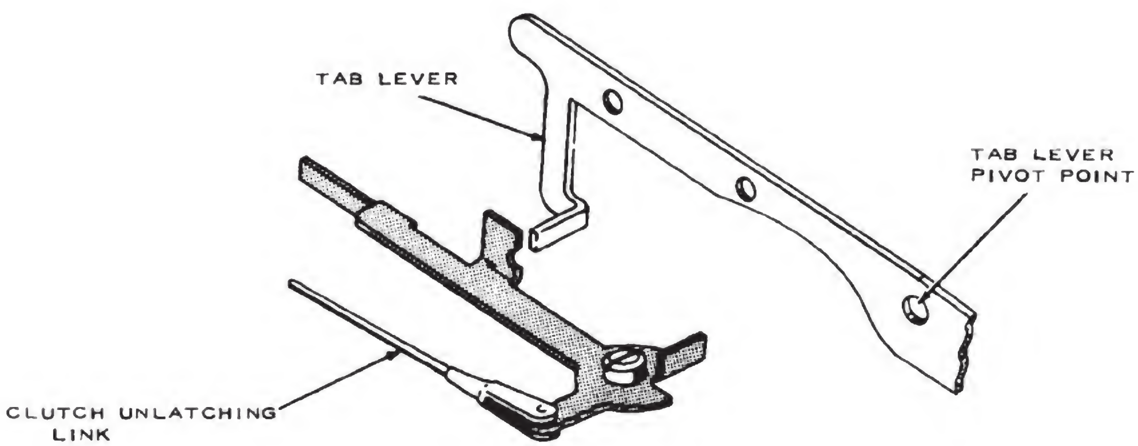

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Figure 4-51.—Carriage Return/Tab Interlock.

SHIFT ACTUATING MECHANISM

The shift mechanism raises and lowers the type basket to provide upper and lower case typing. The basket consists of the segment support, segment, type, and type rest. The assembly is suspended by four segment guides (flat springs), and two toggle springs in the shift actuating mechanism hold the basket to the limit of its upper or lower position.

Up and down movement of the basket is limited by stop brackets mounted on the power frame. The distance the basket moves in going from one case to the other is called SHIFT MOTION. This distance corresponds to the distance on the type slug from the foot of the upper-case character to the foot of the lower-case character. Most IBM electric typewriters have a motion of .265 inch, but a few of the larger types have a motion of .300 inch. Shift motion is

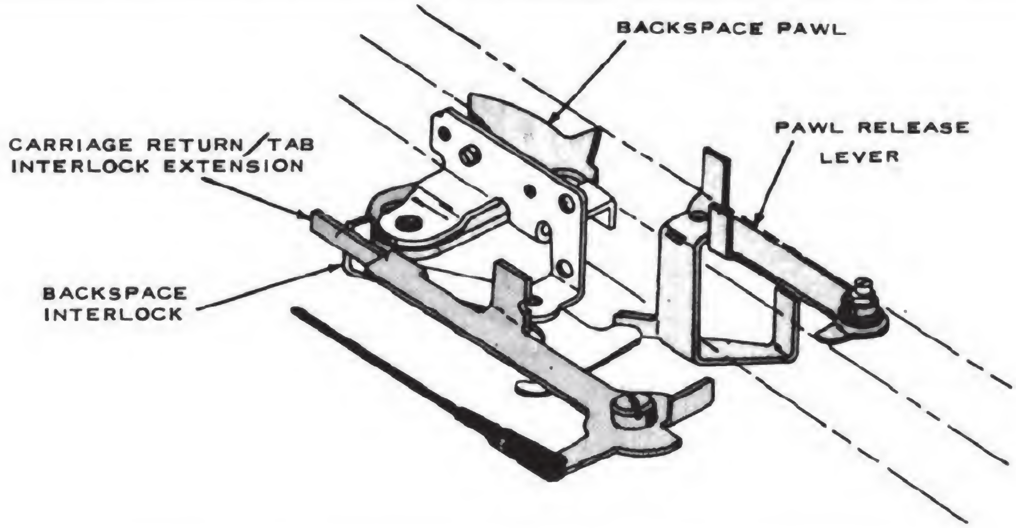

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Figure 4-52.—Interlock, Carriage Return and Backspace.

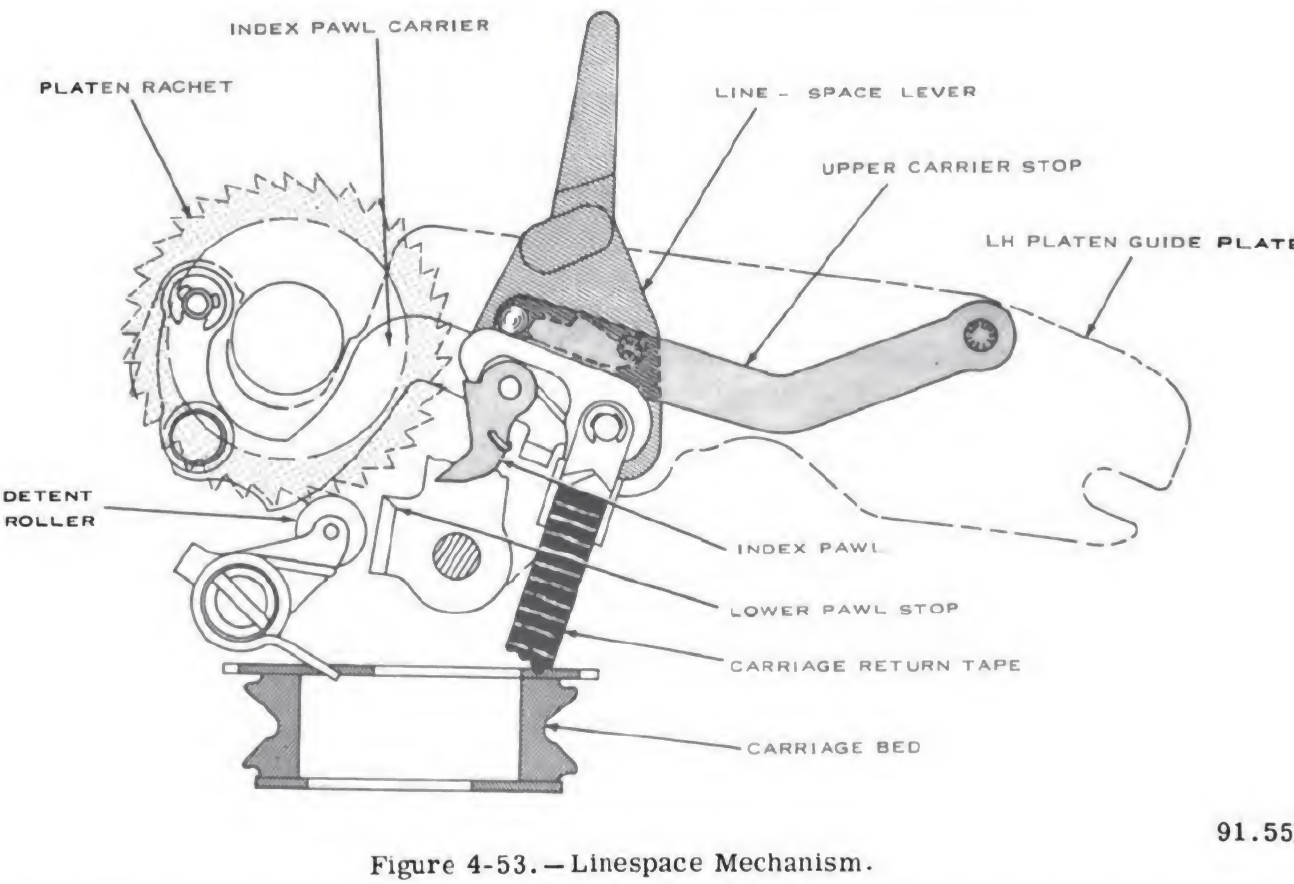

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Figure 4-53.—Linespace Mechanism.

adjusted by the nuts on the stop screw, which regulates the distance between upper and lower bumper washers. This adjustment is correct when upper and lower-case characters print on the same writing line.

Study the shift actuating mechanism shown in figure 4-55. Toggle links at the left and right sides of the basket assembly connect the segment support to a toggle and shaft assembly. The toggle levers are fastened to each end of the

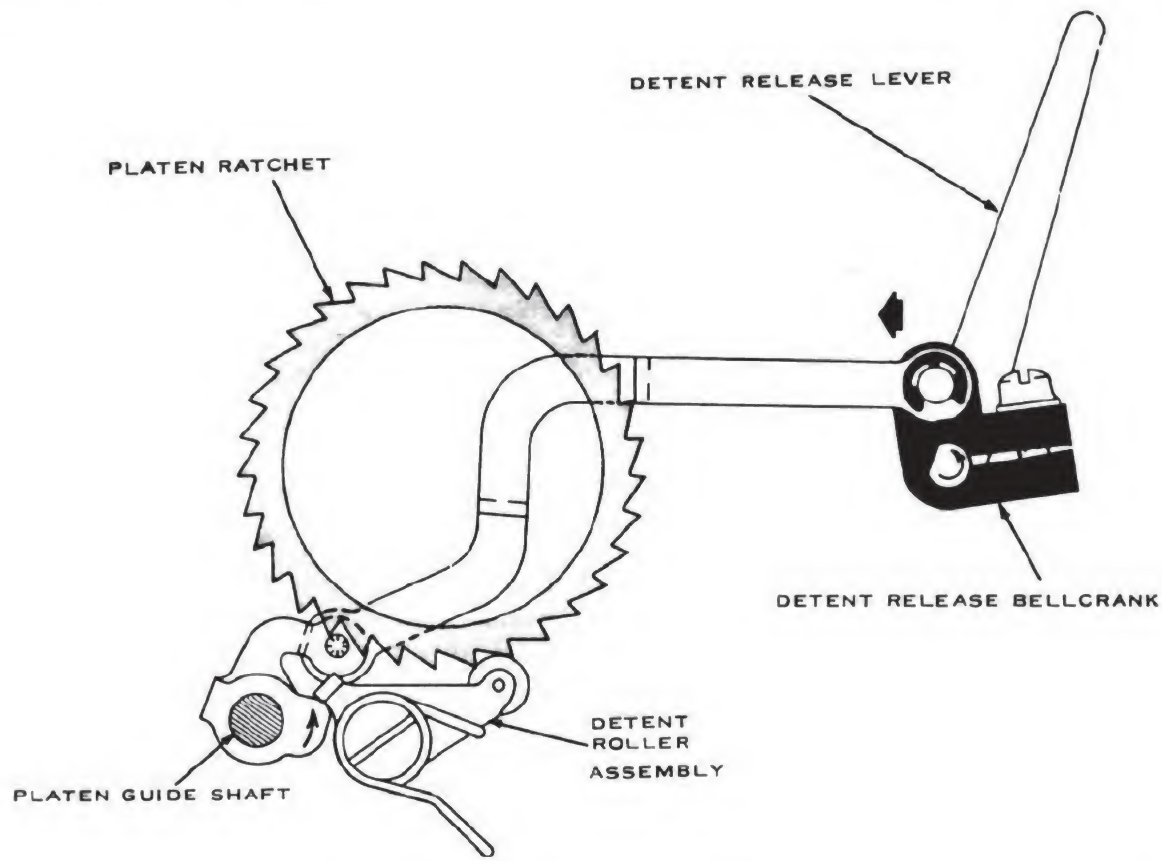

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Figure 4-54.—Detent Release Mechanism.

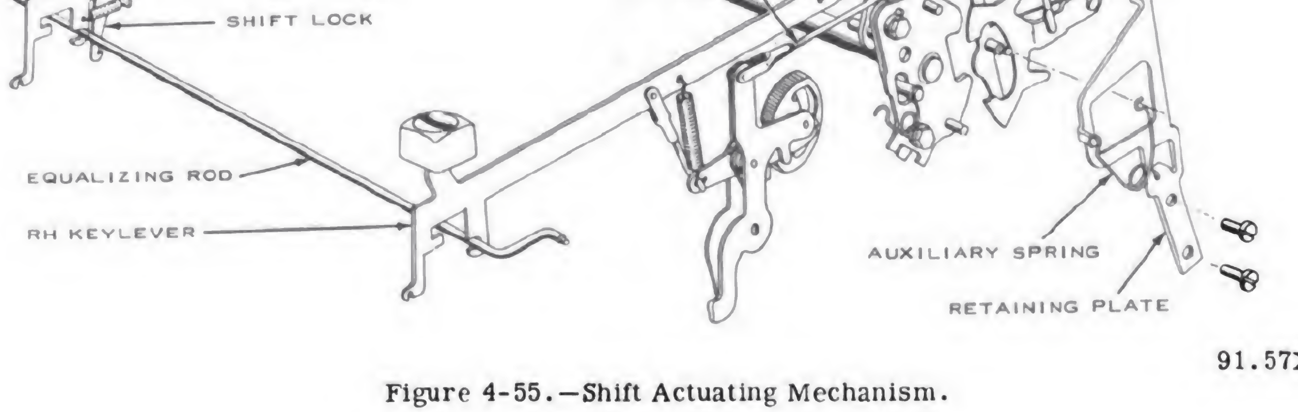

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Figure 4-55.—Shift Actuating Mechanism.

shaft, which is mounted in bearings in the power frame. Rotation of the shaft and toggle levers moves the toggle links up or down to shift the basket. Two heavy toggle springs (mounted between studs on the side frames and studs on the toggle levers) hold the basket assembly in either the fully raised or lowered position. These springs also help to move the basket during shifting.

RH Toggle Lever

The RH toggle lever has a shift plate assembled to it, as shown in figure 4-56. The upper and lower pins illustrated receive the action from the shift cam. Holes for the pins are elongated to allow for adjustments, to provide equal pusher-to-pin clearance on upper and lower pins.

Toggle levers on both sides of the machine are secured to the shaft in matched positions so as to obtain equal toggle action on each side. They are not adjustable. Cam action on the upper pin of the shift plate rotates the toggle levers and the shaft assembly to pull the basket DOWN. Cam action on the lower pin pushes the basket UP. The shift cam is a double-lobed, double-acting type. Double acting means that the cam is released to rotate over one lobe when the key button is depressed, and released again to rotate over the second lobe when the key button is released.

Shift Pusher and Lever Assembly

The shift pusher and buffer (fig. 4-57) are riveted to the shift actuating lever. An adjustable link connects the right shift keylever to the pusher lever. When the front end of the keylever pivots down to release the shift cam, the rear end of the keylever pivots up and positions the pusher behind the upper pin at the time of release of the cam.

The buffer (lever) moves forward and backward with the pusher lever (fig. 4-57). The buffer is a shock absorber which prevents the basket from slamming noisily into position. It engages the lower pin of the shift plate after the pusher rotates the plate by means of the upper pin. The buffer limits the rotating speed of the shift plate to the speed of the buffer as it moves to the rear. The shift cam (symmetrically oval) remains engaged with the power roll even after it passes over the high point. The shift pusher and buffer therefore restore to the rest position ONLY as fast as the rotation of the cam and power roll permits.

When one shift key button is depressed, the other shift key button is also depressed through the equalizing rod. As the rear of the shift keylever rises, it lifts the pusher link and the shift pusher lever. The pusher lever rises until its upper arm is directly behind the upper pin of the shift plate (part A, fig. 4-58). The same keylever operation also lowers the cam release link to release the cam to the power roll. As the cam rotates to its high point, it pulls the operating link forward. The operating link pivots the actuating lever about its mounting screw to bring the pusher and buffer forward. This action causes the shift plate and toggle levers to rotate counterclockwise against the tension of the toggle spring.

Rotation of the shift plate and RH toggle lever assembly by the pusher causes rotation of the actuating shaft and the LH toggle lever assembly. When the cam reaches its high point, the

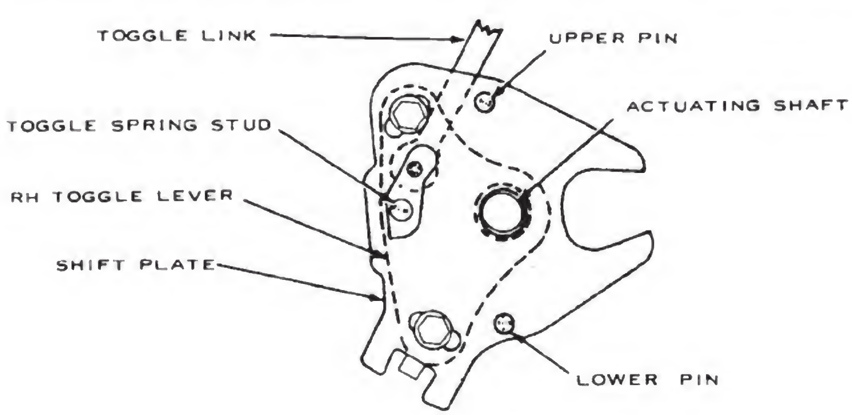

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Figure 4-56.—RH Toggle Lever and Shift Plate Assembly.

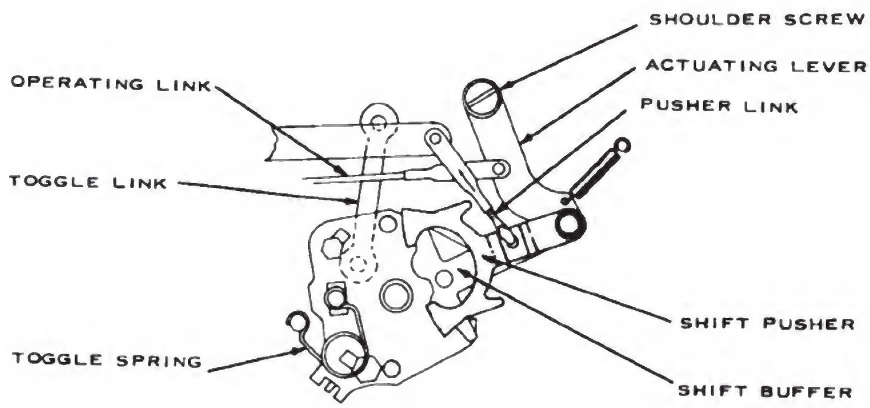

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Figure 4-57. Shift Pusher and Lever Assembly.

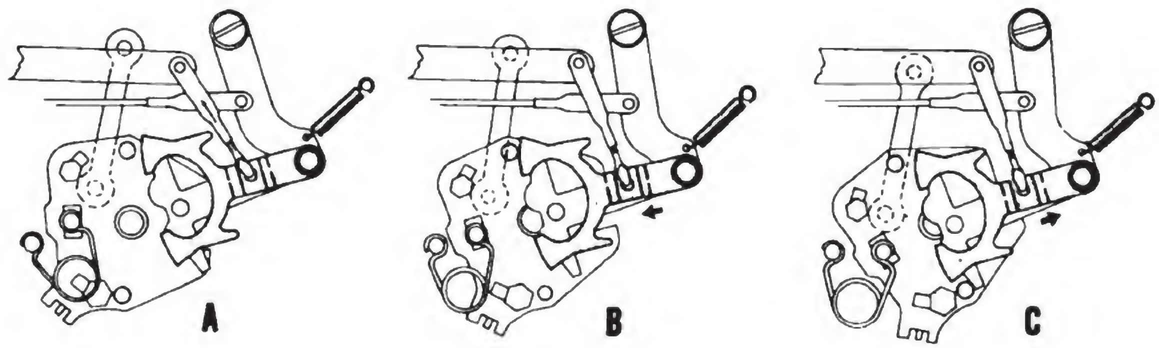

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Figure 4-58.—Shift Actuating Sequence.

pusher action ceases (part B, fig. 4-58). During the preceding action, the buffer moved forward with the pusher but did no work. As the right and left toggle links pull down on the basket, the momentum of the basket continues the rotation of the toggle and plate assembly and the upper pin leaves the pusher. This rotation carries the toggle springs over center and their spring tension then powers the operation to its completion.

As the shift plate assembly continues to rotate, the lower pin contacts the lower arm of the buffer (part C, fig. 4-58). Restoration of the buffer to the rear is controlled by the receding surface of the cam still engaged with the power roll. Cam action slows down the restoring action of the toggle springs to prevent slamming of the segment support against the stop brackets.

BACKSPACE MECHANISM

The backspace mechanism of the C-1 typewriter is shown in figure 4-59. When the backspace keylever is depressed, a link between it and the backspace cam overcomes the tension of the cam release lever spring and releases the single-lobed cam to the power roll. As the cam rotates on the power roll, an operating link connected to the top of its frame causes the backspace bellcrank to rotate and pull the rear link attached to the backspace pawl.

Mounted through an elongated hole, when pulled to the right, the backspace pawl is cammed into the escapement rack (part A, fig. 4-60). Two springs connected to the head of the backspace pawl delay the movement of the head to the right until the backspace pawl is engaged in the escapement rack (part B, fig. 4-60). A guide lug (shown) directs the pawl tip to bottom safely on a rack tooth. When the pawl engages a tooth of the rack, pull on the linkage pivots the pawl on its mounting stud and moves the carriage to the right (part C, fig. 4-60). This motion continues until the carriage moves far enough to

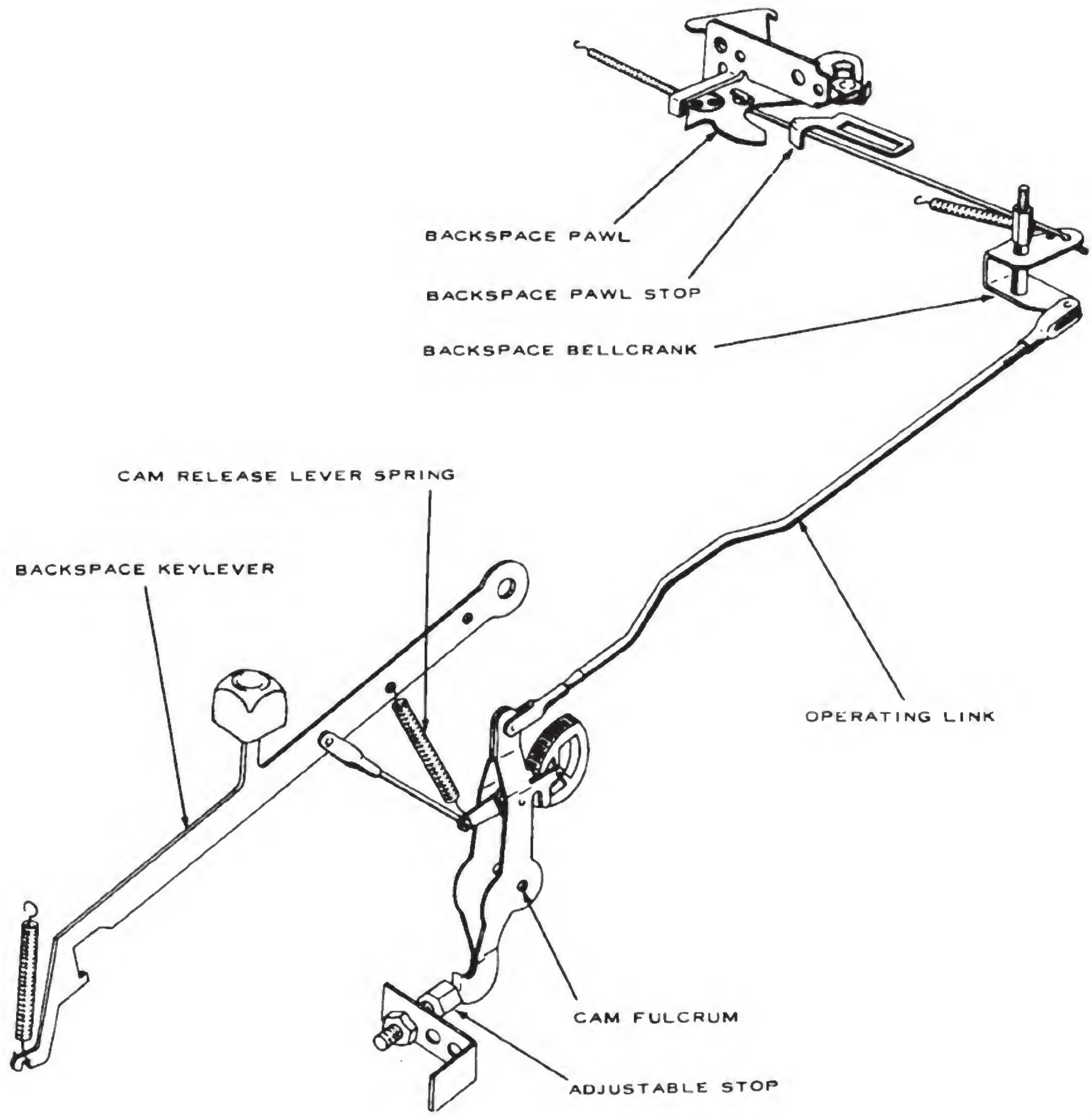

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Figure 4-59.—Backspace Mechanism.

allow the escapement pawl to snap into the next tooth of the escapement rack (part D, fig. 4-60). At this point, the backspace pawl stop halts the backspace pawl, which then prevents further motion of the carriage to the right.

A backspace interlock mounted on the backspace pawl bracket performs two functions:

1. It prevents backspace operation any time the escapement pawl release lever is operated.
2. It prevents pawl release any time the backspace is operated.

Study the backspace interlock shown in figure 4-61. It is actuated by the pawl release lever during tabulation, carriage return, or manual carriage release. This interlock does not prevent the backspace pawl from rotating, but it does prevent the pawl from engaging the escapement rack, by holding the pawl at its mounting stud to keep it from sliding into the rack. The backspace cam operates the linkage; the pawl merely pivots on the lug of the interlock and passes clear of the escapement rack and pawl stop.

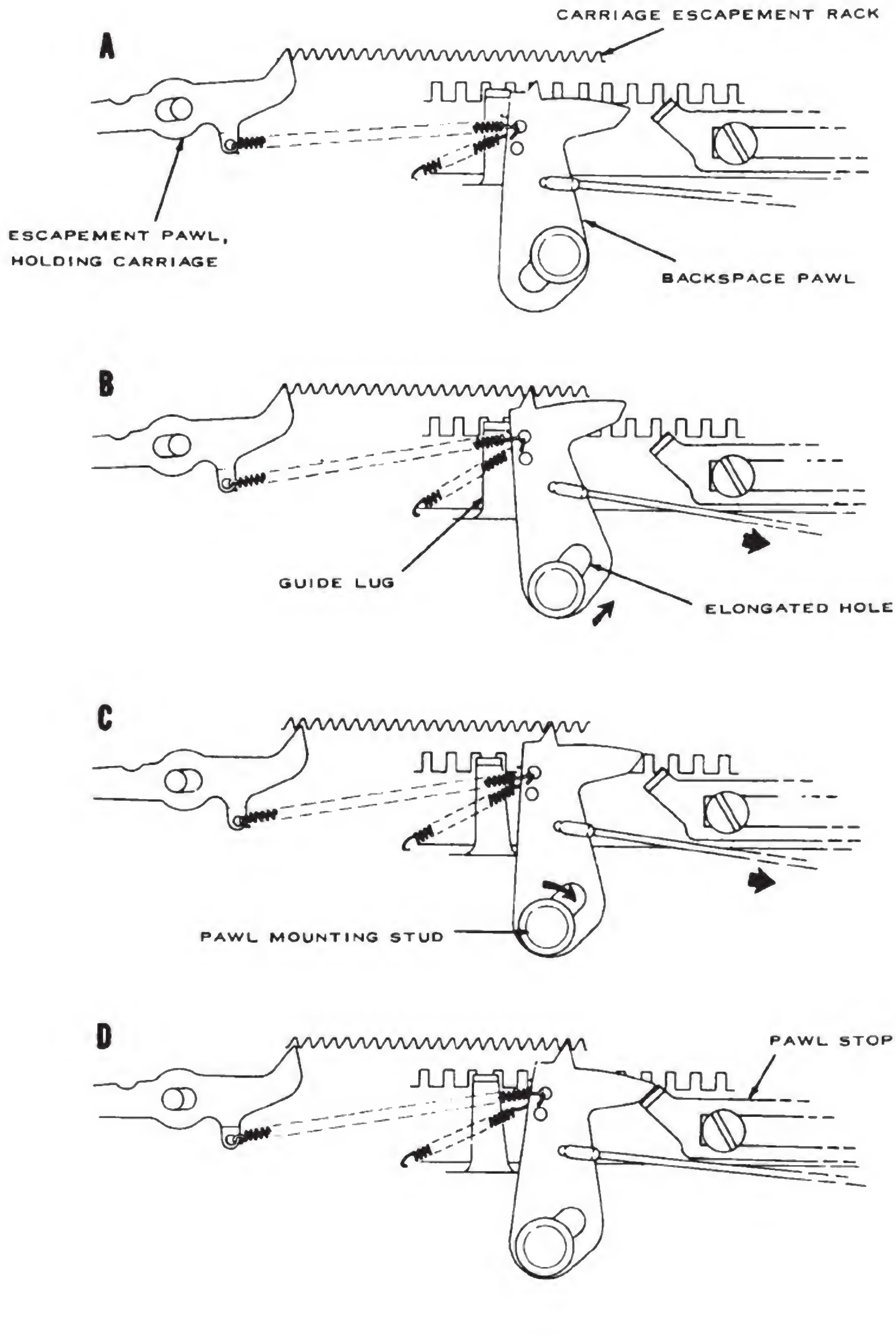

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Figure 4-60.—Backspace Pawl Sequence.

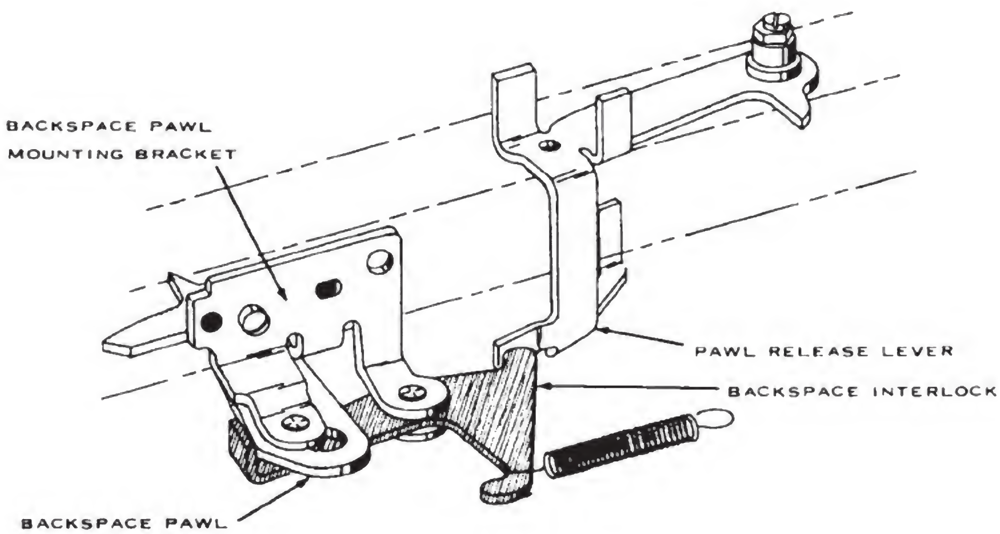

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Figure 4-61.—Backspace Interlock (Rear View).

If the backspace pawl has already entered the escapement rack for a backspace operation, the interlock is blocked and cannot rotate. In this manner, the interlock blocks the pawl release lever and prevents it from pulling the escapement pawl out of the rack, which prevents movement of the carriage.

RIBBON MECHANISMS

The different ribbon mechanisms discussed in this section are: ribbon lift, ribbon feed, ribbon reverse, and ribbon rewind. The ribbon lift and ribbon feed mechanisms are the two major ones. Each mechanism is discussed in as much detail as space permits.

Ribbon Lift Mechanism

Because it is important to have the line being typed visible, a typewriter ribbon rests below the line of type. The ribbon must therefore be raised before the typeface each time a type bar is raised for printing. Letter cams provide the motion necessary to raise the ribbon when the typeface approaches the platen. A restoring spring returns the ribbon lift mechanism to its rest position after a typeface prints.

A ribbon position lever on the keyboard has four positions for controlling the height of ribbon lift, three lift positions and a stencil position (ribbon not raised). The three ribbon lift positions enable a typist to utilize the top, middle, and bottom portions of the ribbon.

When a letter cam is operated, it rotates a bail about its mounting studs on the left and right side frames. See figure 4-62. The bail has a ribbon cam release link at its left end, and a ribbon-lift link at the middle. Rotation of the ribbon-lift bail pushes the ribbon-lift link to the rear, causing an actuating lever to pivot and pull forward on the center of a toggle assembly. This action increases the angle between the toggle arms sufficiently to raise the ribbon lift lever from its rest position. The ribbon lift lever then raises the center guide and positions the ribbon in front of the typeface.

The amount of ribbon lift at any time depends upon the angle of the two toggle arms. An operator changes this angle every time he changes the position of the ribbon position lever. Study the illustration to learn how this is accomplished. A link from the position lever rotates a shaft and its attached positioning plate, which controls the angle of the toggle assembly by positioning the lower toggle arm attached to it. A spring-loaded detent roller holds the plate in one of four positions.

Ribbon Feed Mechanism

Every time there is a type bar operation, the ribbon feed mechanism operates. By means of bellcranks and spring clutches, the ribbon feed cam rotates a geared drive shaft. Study figure 4-63. The drive shaft is moved laterally to engage right or left spool mechanisms. When the

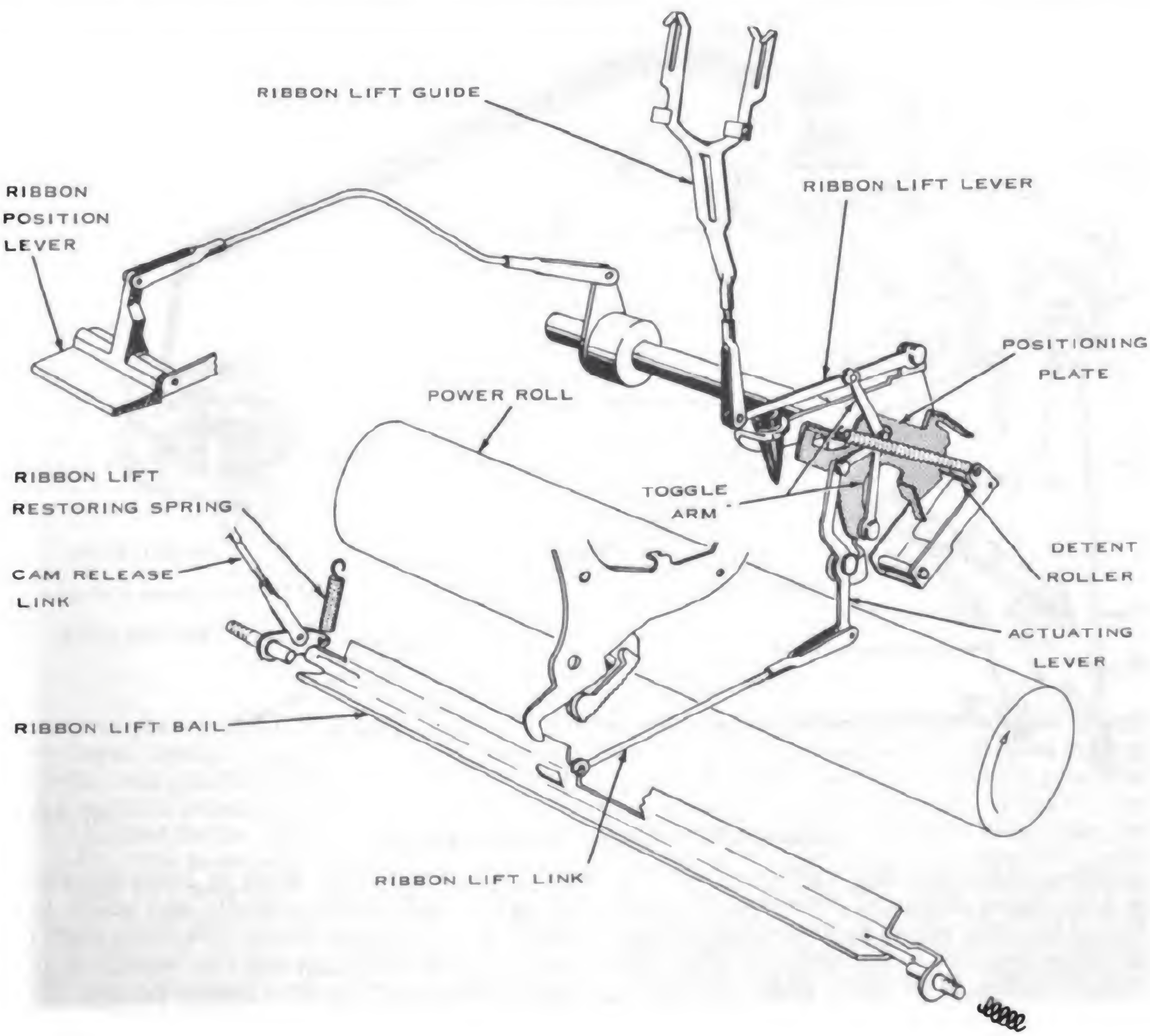

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Figure 4-62.—Ribbon Lift Mechanism.

drive shaft is to the left, the ribbon winds onto the LH spool, and vice versa. The shaft is spring-loaded to the left and the spring holds it in the LH feed position. The shaft is cammed to the right and held in the RH feed position by a latch. Ribbon feed direction reverses automatically when either spool becomes empty.

Operation of any letter cam actuates the ribbon feed mechanism. Rotation of the ribbon lift bail is transferred to the ribbon cam release lever by the cam release link, which is attached to the LH side of the bail. Actuation of the cam release lever allows the ribbon cam to engage the power roll.

When the ribbon cam rotates, it raises the cam frame (fig. 4-63); and an operating link from the cam frame to a ribbon feed bellcrank rotates the bellcrank. A feed link connects the outer arm of the bellcrank to an upper arm on the drive shaft, and motion from the cam and ribbon feed bellcrank causes the upper arm to move up and down.

A spring clutch connects the upper arm to a drive wheel fastened to the drive shaft. When the arm is raised, the spring clutch tightens and turns the drive wheel; when the arm is lowered, the spring clutch relaxes and slips about the drive wheel hub. A second spring clutch and

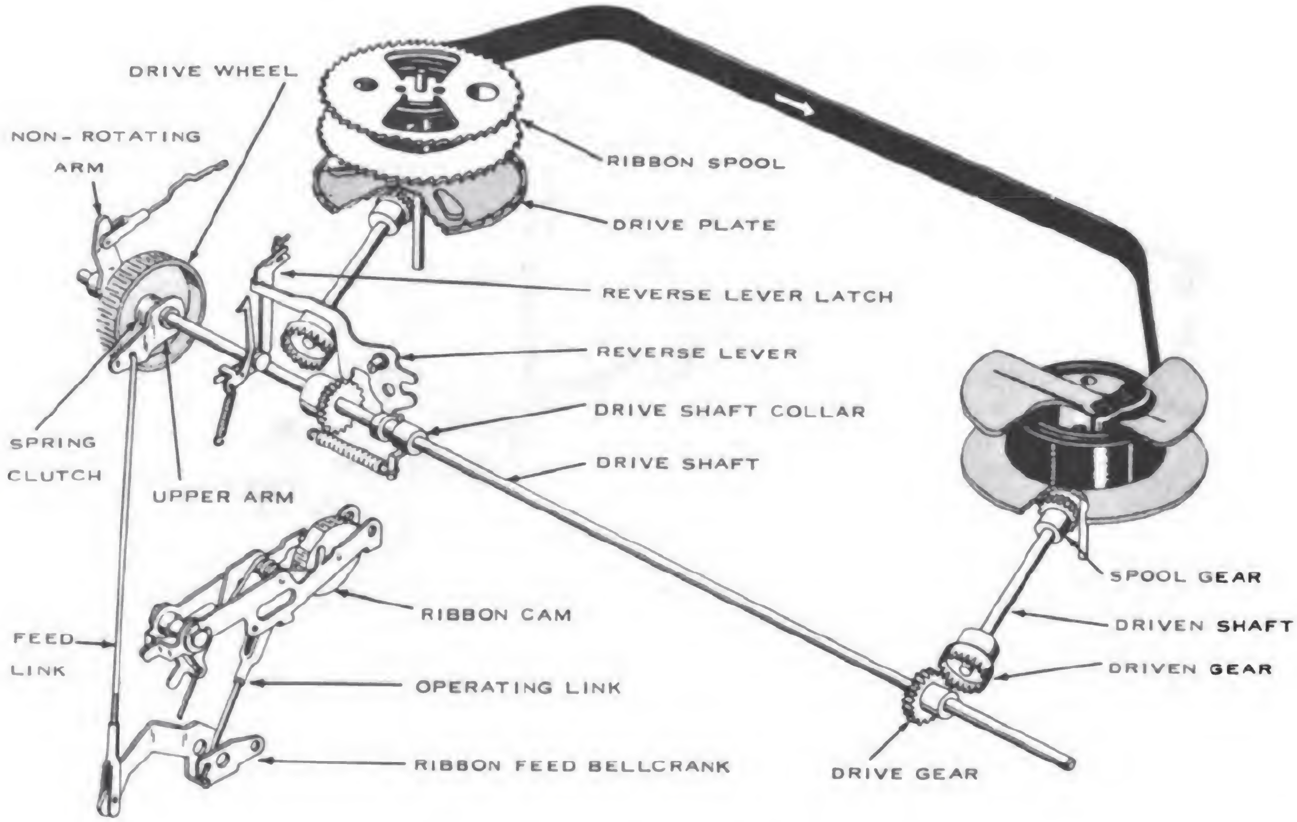

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Figure 4-63.—Ribbon Feed Mechanism.

non-rotating arm assembly tighten when the upper arm moves down and prevents backward rotation of the drive wheel. Reciprocating motion of the ribbon feed link is therefore transformed into rotary motion of the drive wheel and shaft.

Nylon drive gears transfer drive shaft rotation to the ribbon spools through left or right drive shafts. A reverse lever mounted at the left side of the keylever bearing support is keyed to a drive shaft collar fastened to the drive shaft by setscrews. As the drive shaft moves laterally, the reverse lever pivots about its mounting stud on the keylever bearing support. A spring fastened to a lower arm of the reverse lever puts spring tension on the drive shaft to the left.

Ribbon Reverse Mechanism

The ribbon reverse mechanism of the C-1 machine is illustrated in figure 4-64.

A sensing finger of the ribbon reverse mechanism bears against the ribbon of each spool and initiates reverse operation when the spool becomes empty. Feed is reversed when the drive shaft shifts laterally and winds the ribbon onto the empty spool. The drive shaft is moved to the right against the tension of the reverse lever spring by a reversing cam. The right sensing finger operates the reversing cam when the RH spool is empty.

The LH sensing finger is held by a spring which pulls it in a counterclockwise direction. The finger pivots about a shaft on the sensing cam. An eccentric washer mounted on the cam acts on the unlatching lever, which pivots about the same shaft as the sensing finger cam, but it is not connected to the cam.

As the LH spool empties, the LH sensing finger falls into an opening in the hub of the ribbon spool. This movement of the sensing finger rotates the sensing finger cam by acting on a rear upright lug of the cam. Rotation of the sensing finger cam causes the eccentric washer to pivot the unlatching lever to the rear. A link from the unlatching lever pulls the reverse lever

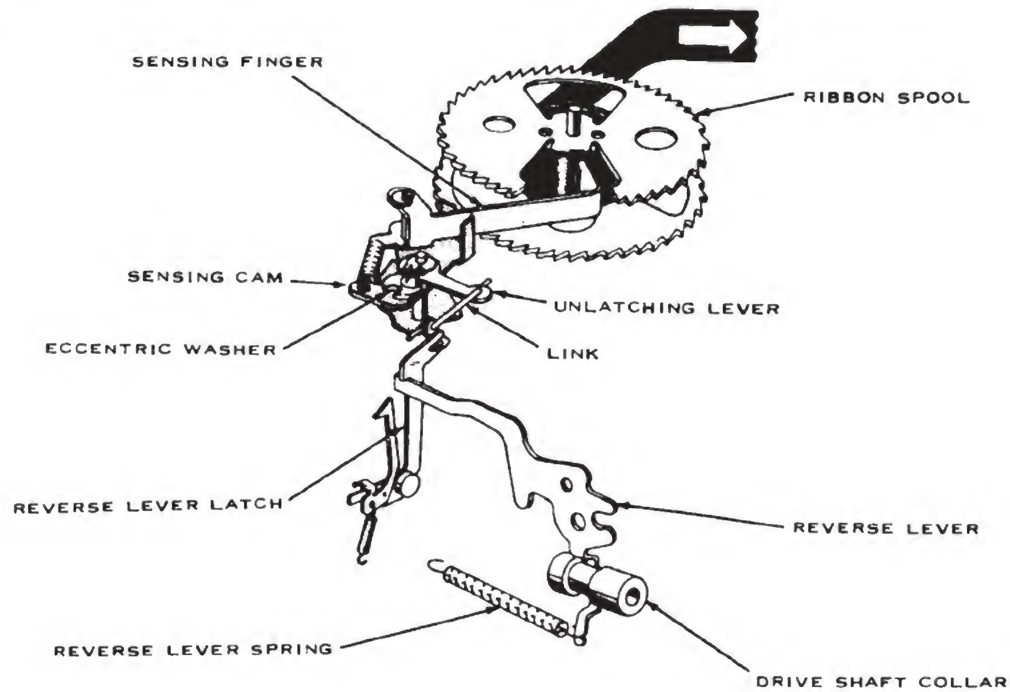

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Figure 4-64.—LH Reversing Mechanism.

latch from the reverse lever, allowing the reverse lever spring to pivot the reverse lever clockwise and pull the shaft to the left.

A two piece primary-secondary cam assembly is attached to the right end of the drive shaft (fig. 4-65). The secondary cam is secured to the drive shaft by a setscrew; the primary cam rotates with it but is not secured to the drive shaft. The two sections of the cam are secured together (spring-loaded) to have them rotate as a unit during normal ribbon feeding. These sections can also rotate independently when forced away from each other. If the primary cam is prevented from rotating, the secondary cam is forced to the right, providing lateral movement of the drive shaft required to engage the RH ribbon spool feed.

The RH sensing finger is welded to a shaft which pivots on the right end of the keylever bearing support, and the RH sensing cam is attached to this shaft by a setscrew. The sensing finger is spring-loaded toward the RH ribbon spool hub by the sensing cam spring, and a reversing pawl is mounted to the right end of the keylever bearing support. An upright stud on the tail of the pawl rides in a camming slot of the sensing cam.

The RH ribbon spool has an opening in the hub that is covered by a plastic gate which prevents the spring-loaded sensing finger from pressing into the spool slot before the RH spool is empty. As the RH spool empties, the plastic gate swings open and the RH sensing finger enters the opening in the spool hub, rotating the RH sensing cam. The cam slot rotates the reversing pawl, and the reversing pawl engages a tooth on the primary cam and stops its rotation. As the secondary cam continues to rotate with the drive shaft, it climbs the camming surface of the primary cam, pulling the drive shaft to the right until the reverse lever latches.

Ribbon Rewind Mechanism

The rapid ribbon rewind feature winds a used ribbon onto the LH spool for changing in approximately 50 seconds. Motion from the power roll pulley rotates the ribbon drive wheel and drive shaft, shown in figure 4-66. Ribbon reverse is interlocked with the rewind mechanism to ensure that the ribbon will be wound onto the LH spool. When the RH spool becomes empty, the RH ribbon reverse action stops the rewind operation.

When the operator depresses the rewind button on the keyboard, the motion is transferred through the button link and button latch to raise the rewind lever. Study figure 4-67.

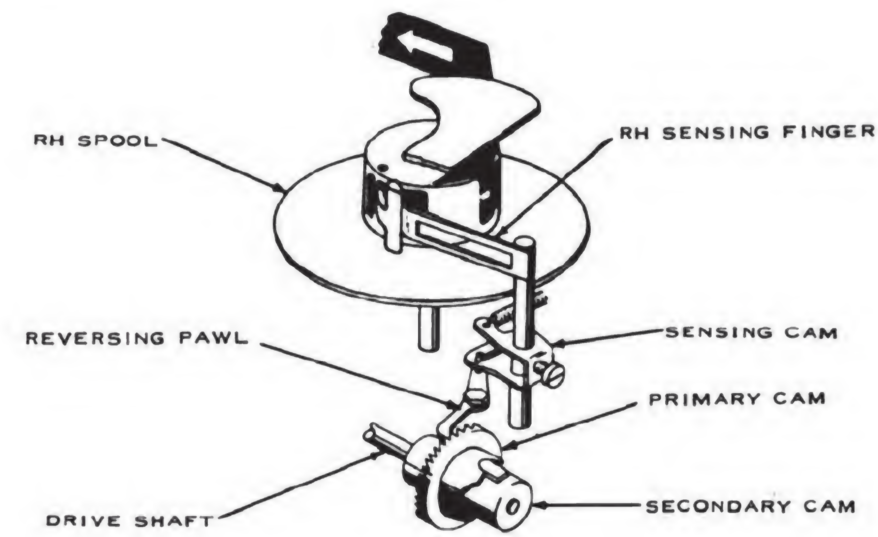

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Figure 4-65.—RH Reversing Mechanism.

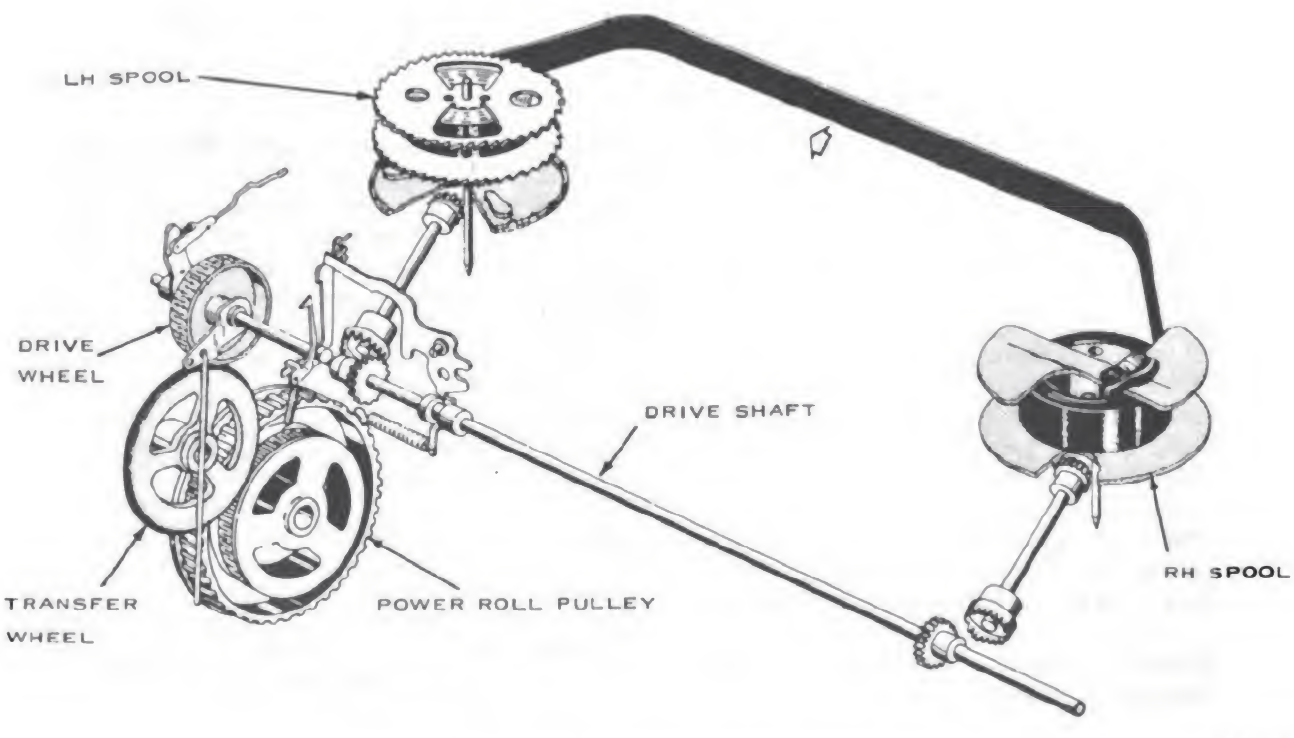

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Figure 4-66.—Rapid Ribbon Rewind Mechanism.

The rewind lever and the transfer wheel bellcrank are linked by a heavy spring (illustrated). As the rewind lever is raised, the bellcrank pivots against the transfer wheel with the power roll pulley and the drive wheel. When the rewind button is fully depressed and the rewind lever fully raised, the rewind latch springs under a lug on the rewind lever and holds the rewind mechanism in the operating position (fig. 4-68). The ribbon then rewinds to the left until the RH spool is empty.

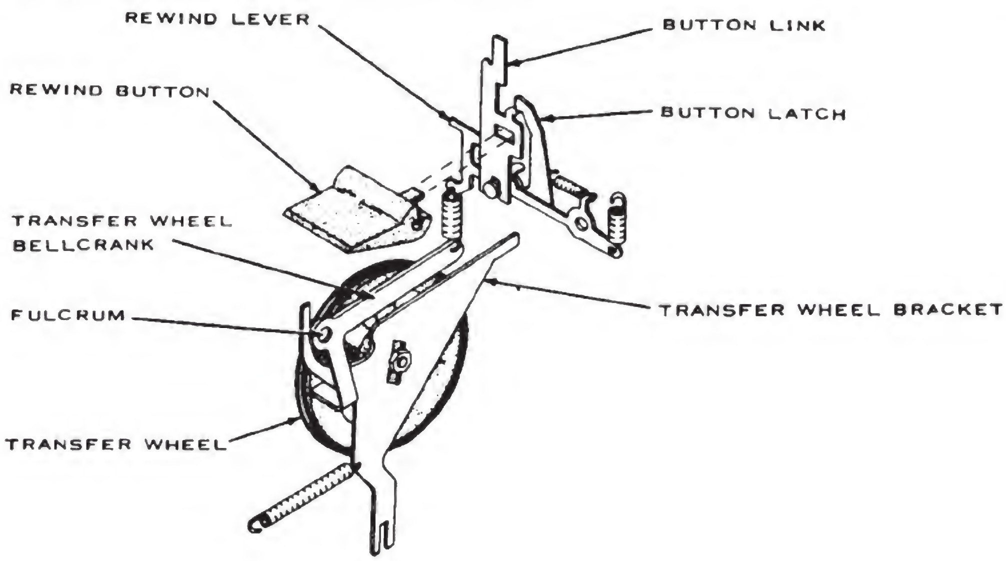

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Figure 4-67.—Rapid Rewind Actuating Mechanism.

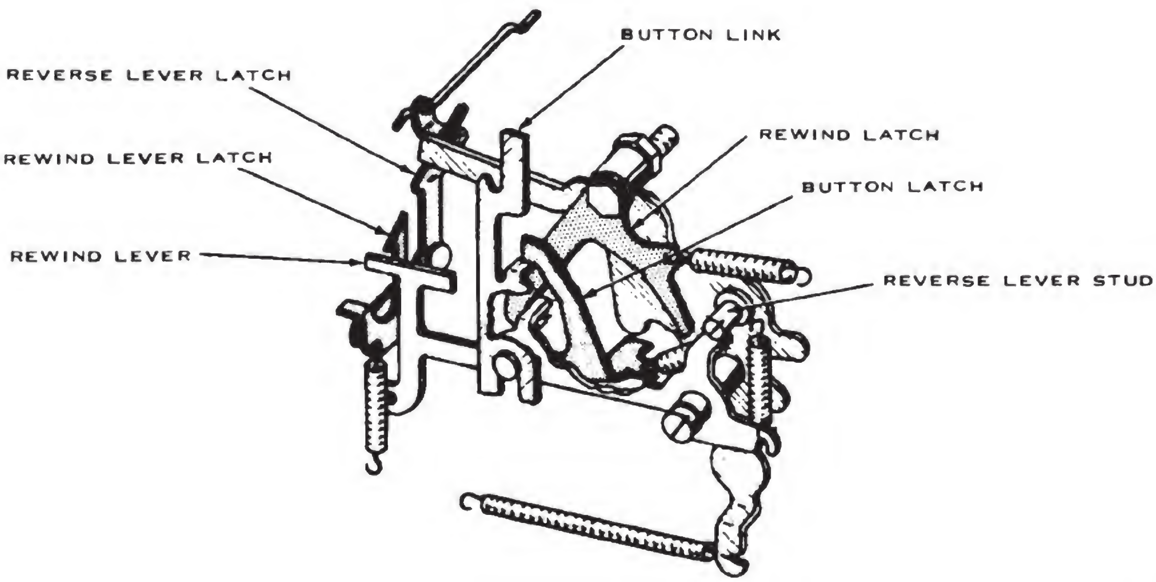

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Figure 4-68.—Rewind Mechanism Latched.

If the ribbon is feeding to the right when the operator actuates the rewind mechanism, ribbon feed must automatically reverse in order that the used ribbon may wind onto the removable spool (LH). With the ribbon feeding to the right, the reverse lever is latched and a rewind lever latch is positioned over the rewind lever, as shown in figure 4-69. When the rewind lever is raised, it engages the rewind lever latch, which pivots the reverse lever latch to the rear. When the reverse lever is released, the drive shaft is free to spring to the left and operate the LH spool for ribbon rewinding.

If the ribbon is already feeding to the left when the rewind lever is raised, no reverse action is necessary. When the reverse lever is unlatched, the rewind lever latch is held to the rear, clear of the rewind lever. When the RH spool empties, ribbon reverse occurs. This action moves the drive shaft to the right and

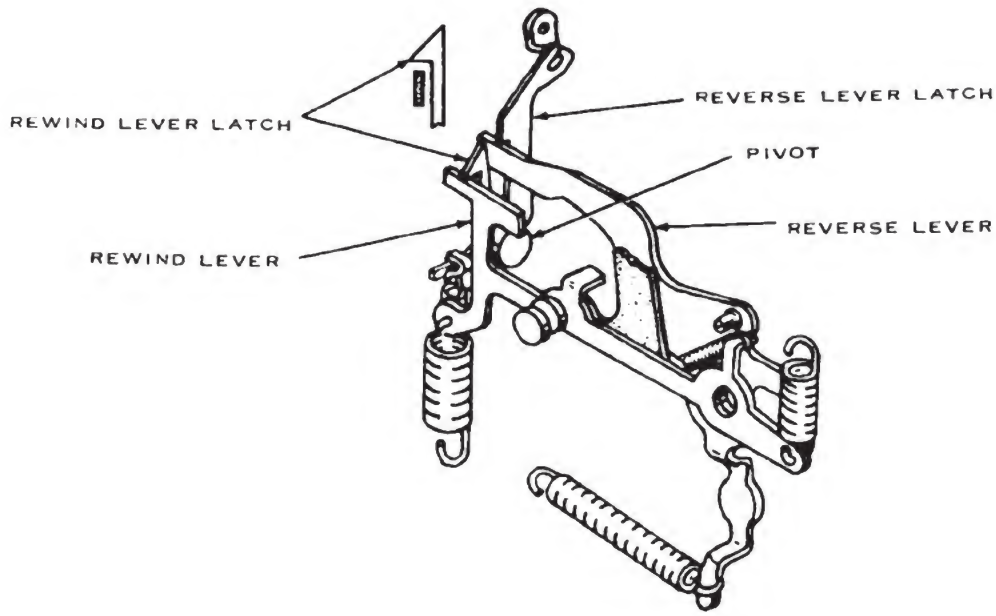

Figure 4-69.—Rewind Lever Latch.

91.71X

rotates the reverse lever counterclockwise. As the reverse lever latches, a stud on the reverse lever strikes the tail of the rewind latch to unlatch the rewind lever. When the rewind lever drops, the transfer wheel is disengaged and rotation of the drive shaft stops.

MAINTENANCE AND REPAIR

An attempt has been made in the preceding discussion to give you considerable information about the various mechanisms of an electric typewriter, and to tell you how they operate in the machine. If you have this knowledge and understanding, you can do a much better job analyzing and remedying casualties to the typewriter, and making adjustments necessary to have all parts and mechanisms function properly.

The procedure for making a casualty analysis is the same for all makes and models of typewriters. You search for trouble until you find it, with disassembly as necessary. Then you effect repairs or replace parts, and make adjustments. Here is where the difference arises in making repairs to an electric typewriter (s). Parts in different makes and models of machines are different, and adjustments vary accordingly.

DISASSEMBLY

Disassembly of a typewriter is no problem if you follow instructions outlined in the manufacturer's technical manual for the machine. This rule applies to both manual and electric typewriters, even though you have an electrical system and different parts in an electric machine. As you learned previously, disassemble first the most accessible parts, and then continue in a logical manner until necessary disassembly is completed. Be sure to put all removed parts in cleaning trays or appropriate containers to protect them from loss or damage.

CLEANING AND REPAIRING

You learned in Instrumentman 3 & 2, NavPers 10193-B, how to clean a manual typewriter, and the procedure is essentially the same for an electric machine. In cleaning an electric typewriter, of course, you must remove the motor and electrical parts before you submerge it into a cleaning solution. As you know, the same rule applies for all rubber parts which would be damaged by the cleaning solution.

Use the typewriter cleaning solution recommended by IBM for cleaning their machines, or the solution recommended by the Navy. Perchloroethane is good for cleaning the exterior of the machine.

After you clean parts, inspect them for wear and defects. Replace parts which may result in malfunctioning of the typewriter. ALWAYS follow this rule. Some bends in links and shafts can be removed; and some parts can be reformec, but only in accordance with the manufacturer's instructions. Be very careful about reshaping parts of an electric typewriter.

Have an Electrician's Mate inspect the motor and electrical system of an electric typewriter, and effect necessary repairs or replacements.

REASSEMBLY AND OILING

Reassembly of an electric typewriter is the same as disassembly, in reverse order. Follow instructions given in IBM's Customer Engineering Technical Manual for the C-1 machine.

During the reassembly of a typewriter, oil parts which require oil as you replace them. Use enough oil for a particular part, but not so much that it runs over other parts or components. Use only a recommended oil—by the manufacturer of the machine or the Navy.

ADJUSTMENTS

Some adjustments for the C-1 electric typewriter have already been mentioned in this chapter, but this section gives the step-by-step procedure for making adjustments to various parts and mechanisms. For additional details on adjustment, consult the technical manual for the machine.

Motor and Drive

1. Power roll end play.—So position the power roll pulley on its shaft that you have .002" to .010" end play.

2. Driven belt.—Position the intermediate pulley shaft to the extent required to give the driven belt a deflection of approximately 3/8 inch. CAUTION: This shaft has a left-hand thread.

3. Drive belt.—Adjust the motor as necessary in order to have approximately 3/16" deflection of the drive belt.

Keylevers and Cams

1. Letter cam clearance.—Adjust the bearing support as necessary to get a clearance of .015" to .020" between all letter cams and the power roll. Adjusting screws are on the side frame. NOTE: Check functional cam clearance after you make this adjustment.

2. Keylever clearance.—Make the adjustments necessary to get the keylevers to trip their respective cams when the keylevers are 1/32" ± 1/64" from the bottom of the keylever guide comb. All trip levers should restore when the keylevers are released.

3. Individual keylever clearance.—Adjust each keylever for proper clearance. Use a screwdriver to increase the clearance between the lower lug and the cam trip. Depress the keylever in the fulcrum wire hole to lower the lug and close the clearance.

Resilient Keyboard

Use a T-bender (fig. 4-70) to form the spring mounting bracket to the extent necessary to get a .001 to .010" clearance between the spring fingers and the keylevers, as illustrated.

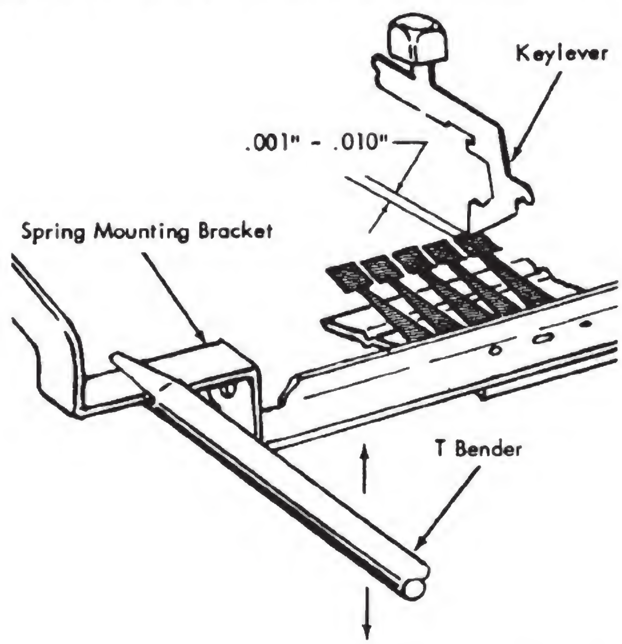

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Figure 4-70. —Resilient Keyboard Operation.

Impression Control

Turn back to figure 4-10 and restudy the description of the mechanism illustrated. Many

factors affect the impression of a typeface. Turn out the impression screw (as a last resort) for light-striking and turn the screw in for heavy impression or cutting. Polish typefaces that do not make strong impressions without cutting the paper. CAUTION: Do NOT cut too deep. Use a recommended abrasive—crocus paper or 600A sandpaper.

The Escapement

Study figure 4-71 as you study how to adjust the escapement. Proceed as follows:

1. Escapement tripping point.—Adjust the left, center, and right type bars so that they trip evenly. Then place the type bars in the position shown in figure 4-71 and loosen the hexagonal head studs to allow the U-bar to assume its normal position. If the left and right type bars trip evenly and the center bars do not trip evenly, form the U-bar support bracket up or down, as necessary, to make proper adjustment.

2. Trip link.—Adjust the trip link (screw top) to have it trip the escapement pawl when the typeface of any bar is 3/8" ± 1/16" from the platen.

3. Upper and lower case tripping point.—Adjust the U-bar adjusting plate up or down until the upper and lower case tripping points are equal. (If there is no adjusting plate, form the trip link lug on the U-bar.)

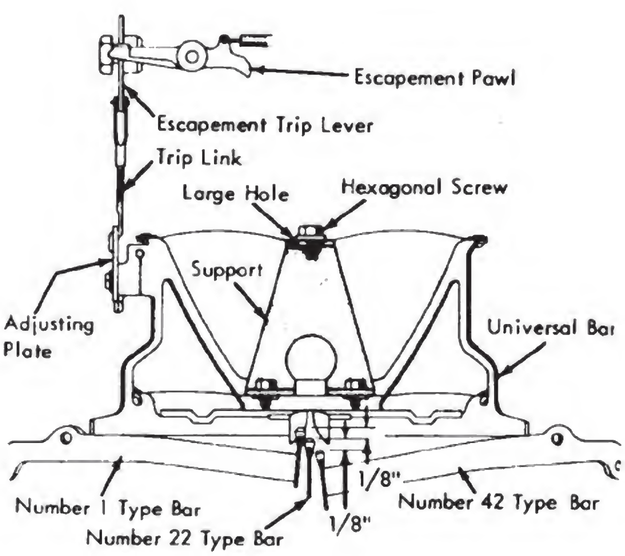

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Figure 4-71.—Adjustment of the Escapement.

Carriage and Rails

Review figures 4-19, 4-20, 4-21, and 4-25. To adjust the carriage and rails, do the following:

1. Front rail.—Move forward and lock in place.

2. Rail support eccentrics.—With the carriage centered and the rear rail screws loose, adjust as necessary to eliminate front-to-rear motion.

3. Rear rail adjusting screws.—With the rear rail screws loose, adjust the rails with the carriage at each extreme margin to eliminate front-to-rear motion. Tighten the rear rail screws.

4. Platen retaining plates.—Adjust as necessary to hold the eccentric collars on the platen guide shaft firmly against the platen adjusting plate.

5. Ring and cylinder.—With a single sheet of bond paper in the machine, and the ribbon in operating position, hold a center type bar in the lower case position against the ring. A strip of bond paper held between the ribbon and paper should then drag slightly when removed. Make adjustments at both ends of the carriage.

6. Feed roll center supports.—So re-position the center supports after making an adjustment of ring and cylinder that they just touch the eccentric collars on the platen guide shaft.

7. Platen latch lever eccentric and platen latch eccentric.—With the high points of the eccentrics toward each other, adjust until the latches meet in one motion and hold the platen bearings without any up or down motion.

Paper Feed Adjustments

Review figures 4-23, 4-24, 4-25, and 4-26. Adjustments of the paper feed mechanism are as follows:

1. With the deflector out (fig. 4-23), so adjust the mechanism that when two tab cards are inserted under the rear feed rolls, the front feed rolls will rotate when the platen is turned; and when five tab cards are inserted, the front feed rolls will not rotate.

2. Support lugs.—So form the support lugs (fig. 4-24) that there is a clearance of 1 to 4 tab cards between the deflector and the platen.

3. Feed roll pressure adjusting screws.—Center the screw plates (fig. 4-24) between the feed rolls and adjust each screw until there is a pressure of 16 to 20 ounces of pressure on

each lever. Pressure between two feed rolls on the same shaft may be equalized by forming the tension spring with long-nose pliers.

4. Line gage card holders.—Adjust the holders until there is a fine white line between the feet of the characters and the reference edge of the card holder. Make adjustments left to right by moving the front dust covers until the lines on the card holder are in line with the bottom of V's typed on paper. Make certain there is a clearance between the platen and the card holders, and that the ribbon center guide does not bind.

5. Indicator pointer.—Center the pointer in the middle of the throat of the type guide.

6. Front paper scale.—With the margin set at 0, so position the scales left or right that the indicator pointer lines up with 0 on the scale.

7. Paper table.—So adjust left or right that graduations line up with the front paper scale.

Margin Set and Release Mechanisms

Margin set and margin release mechanisms are shown in figures 4-27 and 4-28. To adjust them, do the following:

1. Margin set lever.— So adjust this lever that it enters the notch in the margin stop when the carriage is resting at the left margin.

2. Margin set link.—So adjust the margin set link that the margin set lever safely clears the margin stop when the button is released.

3. Margin release tab.—Form the tab on the tab actuating lever as necessary to have the margin control lever clear the margin rack by .010 inch to .015 inch.

Linelock Mechanism

Review figure 4-29. Adjustments for the linelock push rod are:

1. Unhook the push rod and position the carriage at the right margin.

2. Push the switch far enough to the rear to unlock the keylever.

3. Hold a letter keylever down and push forward on the push rod until it stops.

4. Match the pin in the push rod clevis with the hole in the lower linelock bellcrank.

Spacebar Mechanism

The spacebar mechanism of the C-1 typewriter is illustrated in figures 4-36, 4-37, and 4-38. Make adjustments on this mechanism in the following manner:

1. Cam clearance.—So adjust that the release lever lug falls on the rear of the cam lug when tripped (with the power off).

2. Cam release link (former style).—Adjust the cam release link to the extent necessary to have the cam re-set just before the spacebar keylever contacts the keylever stabilizer.

3. Cam release link (present style).—So adjust this link that the cam repeats when the plunger is depressed 1/16 inch.

4. Spring return support.—So form the spring return support that the spring just restores the spacebar to its rest position.

5. Repeat stop (former style).—Adjust the repeat stop vertically until you have from .015" to .025" clearance of the spacebar when the spacebar trips at the non-repeat point.

Decelerator

Review the decelerator illustrated in figure 4-39. To adjust the decelerator, do the following:

1. Spring clutch collars.—So adjust the spring clutch collars that you have from .003" to .005" end play of the arm on the shaft.

2. Spring clutch shaft.—Adjust the end collar as required to get .005" end play of the hub and gear assembly.

Carriage Tension and Governor

Carriage tension of a 12" or 13" carriage should be 2 1/2 pounds. The allowable maximum is 3 3/8 pounds. Carriages 16" or 17" in length have the same starting tension, with a maximum of 3 1/2 pounds.

Make the following adjustments on the centrifugal governor:

1. Pinion gear backlash.—So adjust the governor assembly that the pinion gear teeth have a maximum of .005" backlash with the mainspring drum gear.

2. Governor clutch collar (early models).—So adjust this collar that there is .xx3" to .005" end play in the shaft.

Carriage Return Adjustments

Review illustrations 4-46 through 4-52. Make carriage return adjustments as follows:

1. Cam clearance.—Adjust the cam clearance so that the release lever lug falls on the rear of the cam lug when released (with the power off).

2. Cam release link.—So adjust the cam release link that the cam repeats when the plunger is depressed 1/16 inch. The clevis should be in the rear hole of the keylever.

3. Front clutch lever link.—Adjust the front clutch lever link as necessary to have the clutch lever overthrow its latched position by .010" when the cam is on its high point.

4. Clutch plate clearance.—With the clutch plate held firmly against the disc, set the clutch clearance to .012 inch. Use a feeler gage between the clutch plate and the operating arm.

5. Rear clutch lever link.—So adjust this link that when the cam is at rest the elongated hole (center) in the clutch lever bellcrank is parallel to the rear rail.

6. Clutch latch link.—So adjust the clutch latch link that the elongated hole is in line with the hole in the carriage return tab interlock when the clutch is latched. Place clevis in center hole of bellcrank.

7. Overbank.—Adjust the margin rack left to right so that when the carriage is resting at the left margin there is .070" to .080" (9, 10, 11, 12 pitch) of the tab lever tip showing.

8. Carriage return tab interlock.—With the carriage resting at the left margin, form the left upright lug of the interlock as necessary to get a clearance of .010" to .015" between the tab lever extension and the interlock when the interlock contacts the margin control bellcrank.

9. Clutch unlatching link. —So adjust this link that when the carriage is held firmly against the left-hand margin there is .020" to .025" between the clutch lever and the clutch latch when the clutch is at rest.

10. Clutch tension spring and decelerator.—Move the carriage by hand a few times to the left margin to check deceleration. If it is extremely hard, check the decelerator for binds. Adjust so that it requires a medium amount of effort to move the carriage to the left margin in one motion. Next, put the linespace lever in the triple index position and loosen the tension nut until return just fails. Then tighten the nut until the carriage just returns from 1 to 0. After you finish this adjustment, tighten the nut three full turns.

Tabulator Mechanism

As you make adjustments on the tabulator mechanism, refer to illustrations 4-43, 4-44, 4-45, 4-72, and 4-73. Adjustments for the C-1 machine follow:

1. Cam clearance.—Adjust the cam as necessary to have the release lever fall on the rear of the cam lug when the cam is tripped (with the power off).

2. Cam release link.—So adjust this link that the cam is tripped when the keylever is depressed 1/2 to 3/4 of its downward travel.

3. Tab lever height.—Adjust the actuating lever eccentric or lug until the margin control lever engages the left margin stop by the thickness of its metal.

4. Tab rack.—With the power off and the cam on the high point, allow the carriage to move to the left, so that a set tab stop holds the tab check lever to its extreme left position. Then back the cam slowly from its high point. As the escapement pawl enters the escapement rack, there should be .012" to .017" clearance (fig. 4-72) between the working surface of the rack tooth and the working surface of the pawl.

5. Tab latch eccentric.—So adjust the tab latch eccentric that the tab check lever engages any set tab stop by 1/2 to 2/3 of its exposed surface. Keep the right side of the eccentric to the right.

6. Tab unlatching.—So form the tab latch extension at the point of contact with the tab check lever that the tab unlatches when the tab check lever is .040" to .045" from its full left hand position (fig. 4-73). This happens just before the slot disappears under the head of the RH stud.

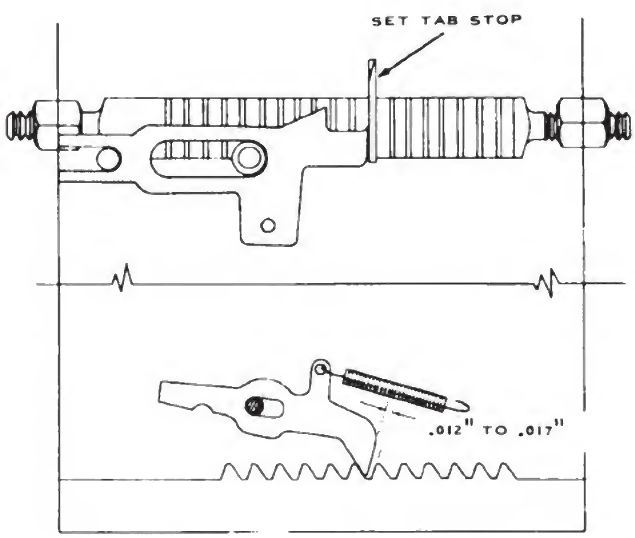

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Figure 4-72.—Adjustment of Escapement Pawl.

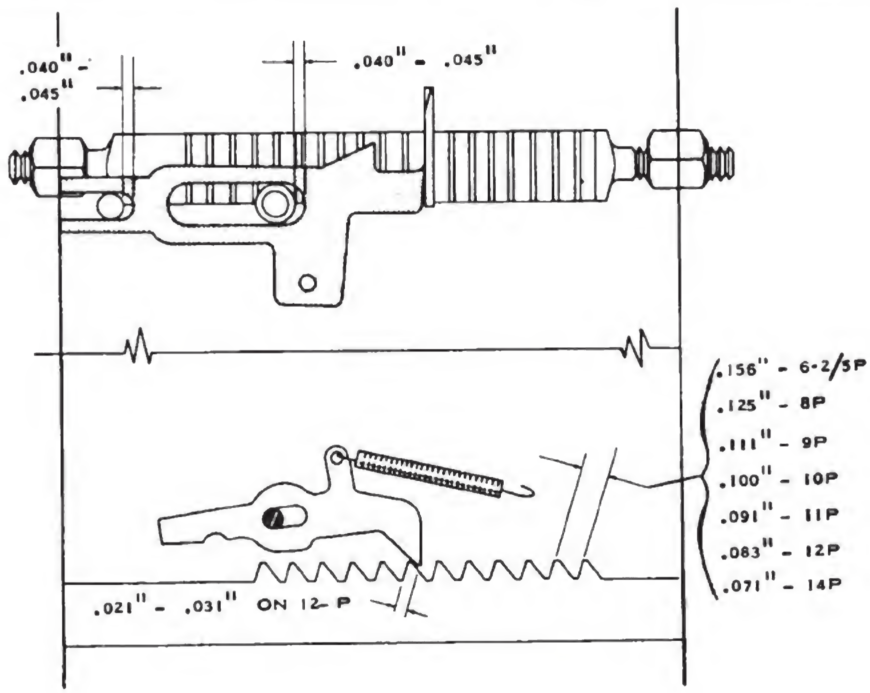

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Figure 4-73.—Position of Tab Rack and Pawl When Unlatching Occurs.

7. Tab check lever keeper.—Adjust this keeper to the right or left, as necessary, to get a clearance of .010'' to .025'' between the working surfaces of the tab check lever and the set tab stop as the tab lever is moved slowly to the rear.

8. Operating link.—So adjust the operating link that the tab lever overthrows its latched position by .015'' to .020'' when the cam is on the high point.

9. Tab lever extension.—With the cam on its high point, there should be a clearance of .001'' to .005'' between the extension and the overthrow stop.

10. Pawl clearance.—Form the rear upright lug on the pawl release lever to the extent necessary to have the pawl clear the rack by .015'' when the tab lever is latched.

11. Decelerator link.—So adjust the decelerator link that you get maximum deceleration without hesitation.

Shift Mechanism

Refer to figure 4-74 as you study the procedure for adjusting the shift mechanism, as follows:

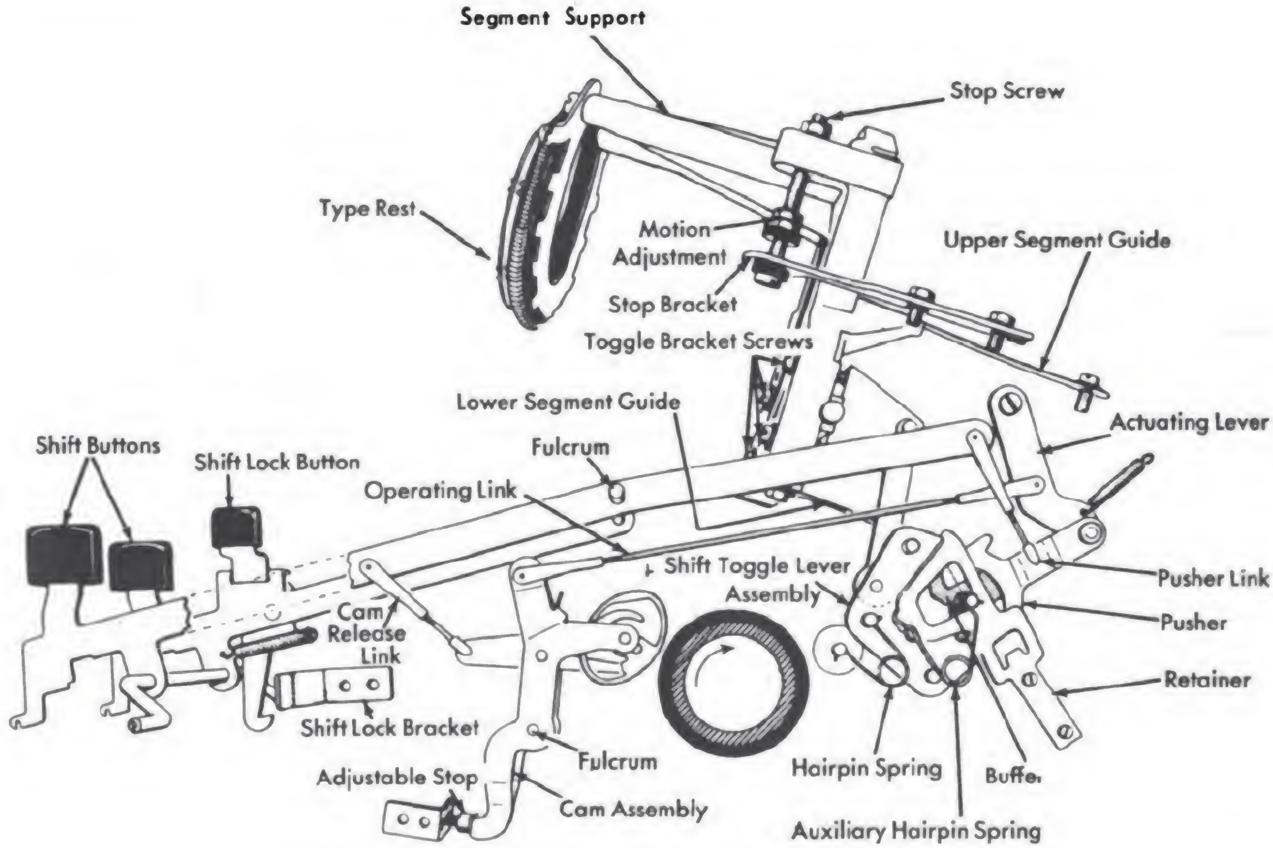
1. Cam clearance.—So adjust that the release lever lug falls just behind the cam lug when the cam is tripped (with the power off).

2. Cam release link.—Adjust as necessary to have the cam release when the keylever is depressed 1/2 to 3/4 of its total travel.

3. Motion.—So position the lock nuts on the stop screw that the upper case characters print on the same line as the lower case characters.

4. Even top and bottom.—This adjustment can be made in two ways: (1) adjustment of the shift stop screw, and (2) adjustment of the segment mounting eccentrics. To adjust the shift stop screw, center the basket between upper and lower case and so adjust the stop screws that the center of the shift toggle shaft and the two shift toggle spring pins are in a straight line (figs. 4-57 and 4-58). Then put the basket in the lower case position and adjust the segment mounting eccentrics for even top and bottom printing. NOTE: Keep the eccentrics in the upper part of their orbit and toward the outside of the basket. Always keep them even to level the basket.

5. Equal pin clearance.—Adjust the shift pin toggle plate sufficiently to have the pusher clear the pins an equal amount in upper and lower case.



91.76X

Figure 4-74.—Adjustment diagram for shift mechanism.

6. Pusher link.—Adjust until the top edge of the upper pusher arm is slightly above the upper pin when the cam is released.

7. Operating link.—So adjust that the pusher clears the pins by 1/32" to 1/16" when the cam is at rest.

8. Shifting off.—Adjust for shifting off ONLY when absolutely necessary. The basket should shift off cylinder from .001" to .012" maximum, as required, to prevent upper case embossing, or for even color between upper and lower case. To increase the shift off, place shims under the front of the top segment guide springs or under the rear of the bottom segment guide springs. Reverse this procedure to reduce shifting off.

9. Shift lock.—Adjust the lock bracket in the amount required to have the basket shift as the lock engages. Use both shift buttons to check for easy unlocking.

Backspace Adjustments

Review illustrations 4-59, 4-60, and 4-61. Make adjustments to the backspace mechanism in the manner explained in the following paragraphs:

1. Cam clearance.—Cam clearance is correct when the release lug falls on the rear half of the cam lug.

2. Cam release link.—So adjust the cam release link that the cam trips when the keylever has completed 2/3 of its downward travel (nonrepeat). For repeat action, adjust the cam release link as necessary to have the cam repeat when the plunger has been depressed 1/16 inch. NOTE: The cam must reset when the keylever is released.

3. Backspace interlock.—So form the interlock mounting bracket that, with the pawl release lever operated, the upright lug on the interlock clears the backspace pawl by a minimum clearance.

4. Pawl release lever lug.—With the interlock at rest, so form this lug that the backspace pawl can move past the upright lug on the interlock with a minimum of clearance.

5. Backspace pawl guide lug.—Form this lug to the extent necessary to have it guide the backspace pawl into the escapement rack with .015" to .025" clearance between the working surface of the rack tooth and the working surface of the backspace pawl.

6. Backspace pawl stop.—Adjust this stop as necessary to have the backspace pawl contact the stop just after the escapement pawl drops into the next rack tooth. Adjust front to rear, so that when the interlock is operated the backspace pawl will clear the stop.

7. Operating link.—Adjust the backspace link 1/2 turn at a time until the carriage just backspaces from 1 to 0.

8. Carriage return tab interlock extension—So form this extension that it prevents the clutch from latching when the backspace mechanism is operated. So form the tip that it just clears the backspace interlock.

Line Spacing

Review figures 4-53 and 4-54. Adjust line spacing by placing the lower pawl stop in such position that it stops downward movement of the index pawl when the detent roller is positioned between two teeth on the platen ratchet. Check for adequacy of adjustment by pulling the return tape by hand until the index pawl contacts the stop. Then release the tape. There should now be no further rotation of the platen in either direction.

CHAPTER 5

REPRODUCING MACHINES

Before you can qualify for advancement in rating to an Instrumentman 1, you must be able to analyze and remedy casualties to direct process duplicators; and before you can qualify for advancement to a Chief Instrumentman, you must be able to ANALYZE and REMEDY casualties to Addressographs and graphotypes, which emboss plates used in Addressographs. All of these machines are discussed in as much detail in this chapter as space permits. Additional information is available in manufacturers' technical manuals for specific makes and models of machines.

FLUID PROCESS DUPLICATOR

The A. B. Dick Model 215 duplicator is discussed in this chapter, as a representative type. You learned in Instrumentman 3 & 2, NavPers 10193-B, how to repair and adjust the A.B. Dick Model 438 STENCIL PROCESS machine. Review the information presented on that machine before you study the parts and mechanisms of the Model 215 fluid process duplicator, which is illustrated in figure 5-1.

PARTS AND MECHANISMS

Refer to applicable illustrations as you study the parts and mechanisms of the Model 215 duplicating machine. Be sure you understand the function of all parts, so that you will understand better how to repair (or replace) and adjust them.

Feed Rolls and Stop Controls

Feed Rolls and Stop Controls in the Model 215 duplicator are shown in figure 5-2. Note the parts in the rectangle to the right of the illustration, with an arrow pointing to their location in the machine. Study the nomenclature carefully.

When the handle of the paper separator lever is pressed down, the lever contacts the forward ends of the right and left paper separators and pivots them upward, to act as paper stops during loading.

The feed cradle may be raised or lowered manually. When you lift the cradle, the feed cradle latch locks to engage an ear on the right end of the feed roll cradle and hold the cradle assembly in the UP position. To lower the cradle and feed rolls, press inward on the feed cradle latch lock.

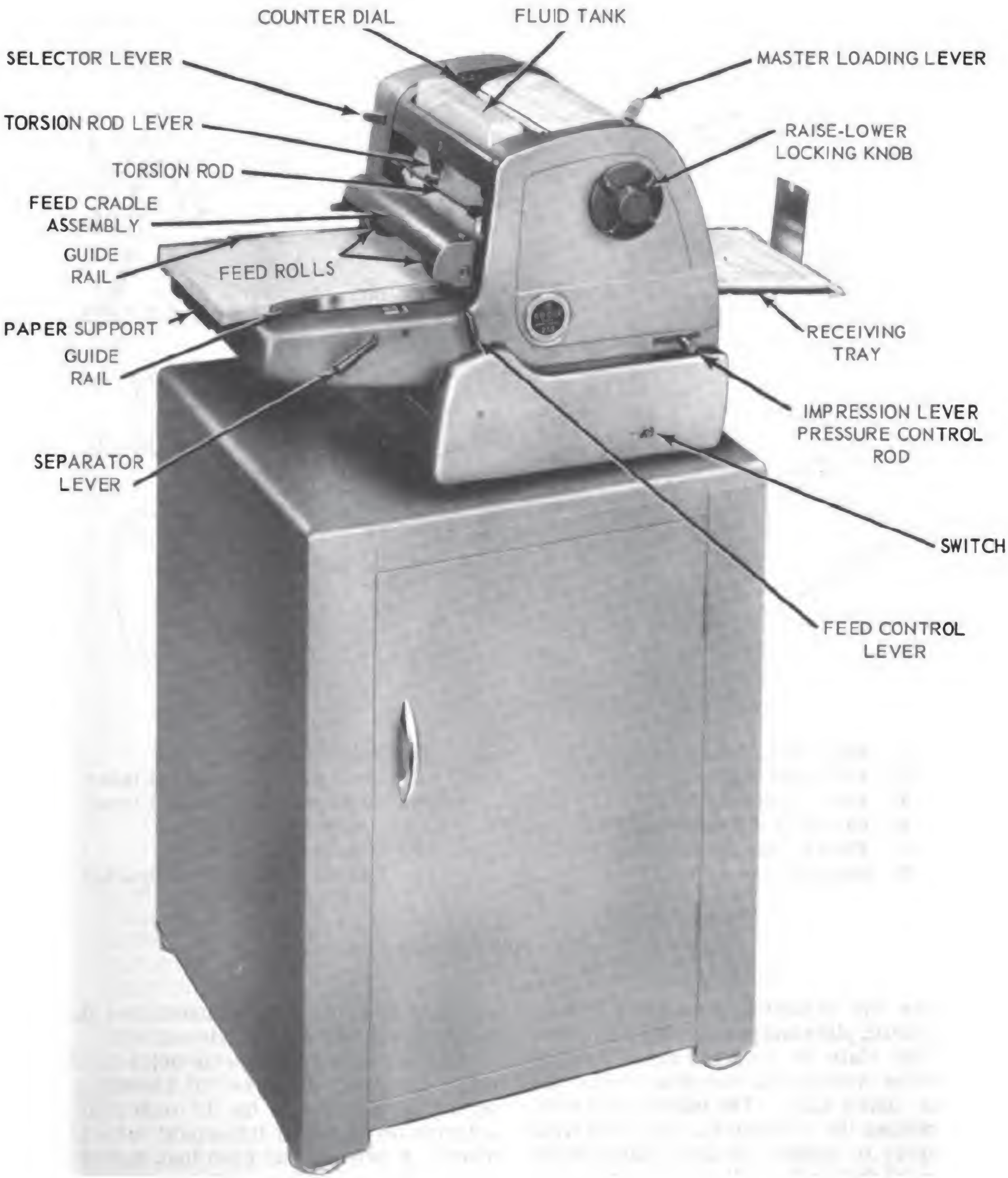
When the feed rolls are down (in feeding position), downward movement of the handle of the separator lever causes the left end of the lever to engage the feed roll locking lever assembly (cradle raising lever and bracket) and raise the feed roll cradle and paper separators, locking them in the UP position.

The feed pressure control lever (fig. 5-2) serves to counterbalance the feed roll and cradle assembly. When the lever is in the HIGH position, the full weight of the feed roll assembly is on the paper. As you move the lever to the LOW position, tension on the feed pressure control lever spring increases. The increased spring tension counterbalances the weight of the feed roll and cradle assembly, thereby decreasing the pressure of the feed rolls on the paper.

Motor Drive and Feed Control

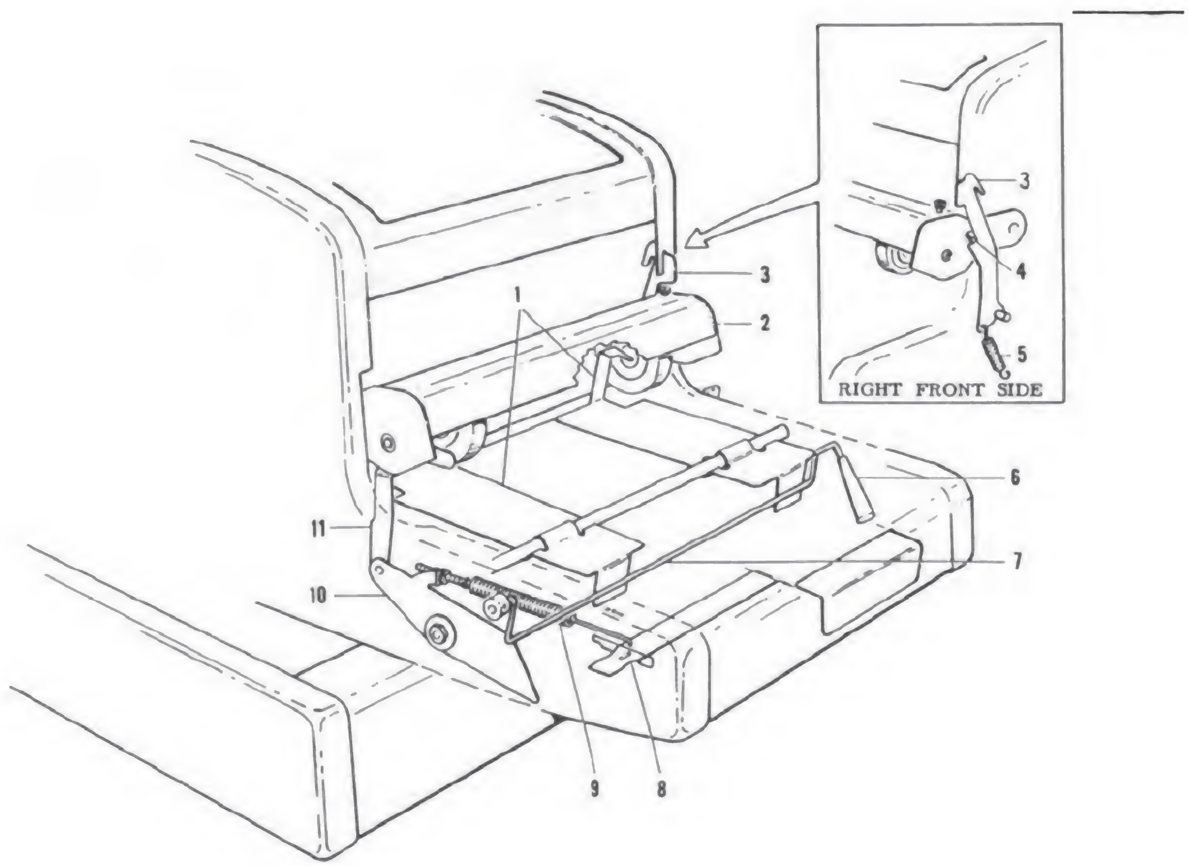
When you turn the motor switch on, the motor drives the clutch pulley. Study the nomenclature in figure 5-3. Note the V-shaped belt over the motor and clutch pulleys.

The clutch pulley runs FREE (free wheeling) until you pull the feed control lever toward the front of the machine, which movement causes the cam lever to pivot upward and hold the clutch drive lever and hub assembly extension lever DOWN. Downward movement of this extension



91.77X

Figure 5-1.—A. B. Dick Model 215 fluid process duplicator.



1. Paper separators
2. Feed roll cradle
3. Feed cradle latch
4. Ear on feed cradle latch
5. Feed cradle latch spring
6. Separator lever handle
7. Separator lever
8. Feed pressure control lever
9. Feed pressure control lever spring
10. Cradle raising lever
11. Cradle raising lever bracket

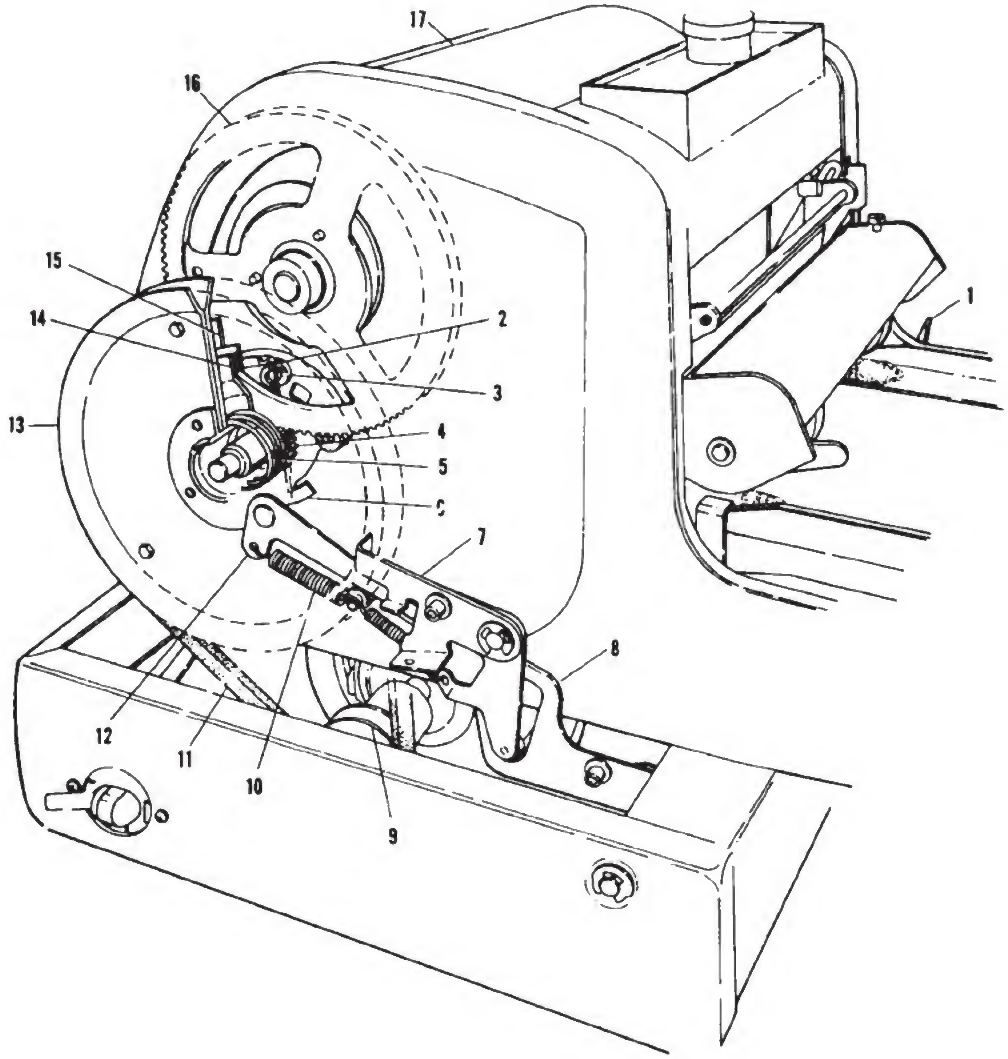
91.78X

Figure 5-2.—Feed roll and stop controls.

lever forces the actuating plate pawl DOWN, and the actuating plate and pawl spring then cause the actuating plate to pivot counterclockwise and the brake washers to disengage from the face of the clutch plate. The pulley and clutch spring continues the action by forcing the driving disk assembly to contact the disk pulley, which (with its gear) drives the cylinder gear to rotate the cylinder.

If you press the feed control (cycling) lever toward the rear of the duplicator and then release it (fig. 5-4), the movement forces the clutch driver lever down and causes the clutch pulley to revolve the cylinder once.

The selector lever spring holds the selector lever in either the 11- or 14-inch position. When the lever is in the 11-inch position, the selector lever spring lifts a pawl on the actuating lever. A stud on this pawl then moves into the path of the upper cam follower, whose spring causes the cam to follow the contour of the cylinder cam. As the upper cam follower moves to the LOW part of the cylinder cam, the actuating lever spring causes the actuating lever to



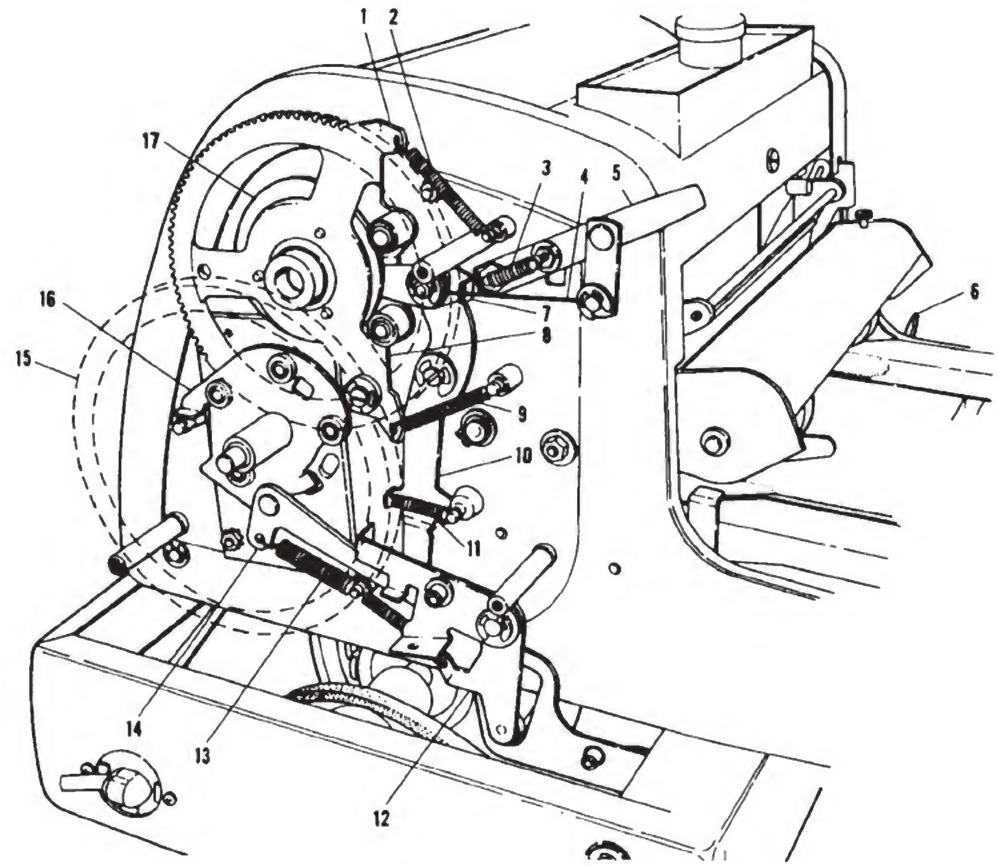
1. Feed control lever
2. Clutch plate
3. Brake washers
4. Disk pulley drive gear
5. Pulley and clutch spring
6. Actuating plate
7. Extension lever and hub assembly
8. Cycling lever cam
9. Pulley
10. Actuating plate and pawl spring
11. Belt
12. Actuating plate pawl
13. Clutch pulley
14. Driving disk assembly
15. Disk pulley
16. Cylinder gear
17. Cylinder

91.79X

Figure 5-3.—Driving Mechanism.

pivot counterclockwise. The actuating plate and pawl spring then cause the pawl actuating plate and pawl assembly to move up and engage the lower end of the actuating lever.

When the upper cam follower moves to the HIGH portion of the cylinder cam, it contacts a stud on the end of a pawl on the actuating lever and causes the actuating lever to pivot clockwise.



1. Upper cam follower
2. Upper cam follower spring
3. Selector lever spring
4. Cam follower spring
5. Selector lever
6. Speed control lever
7. Actuating lever pawl
8. Lower cam follower
9. Lower cam follower spring
10. Actuating lever
11. Actuating lever spring
12. Clutch drive lever
13. Actuating plate and pawl spring
14. Actuating plate pawl
15. Clutch pulley
16. Actuating plate
17. Cylinder cam

91.80X

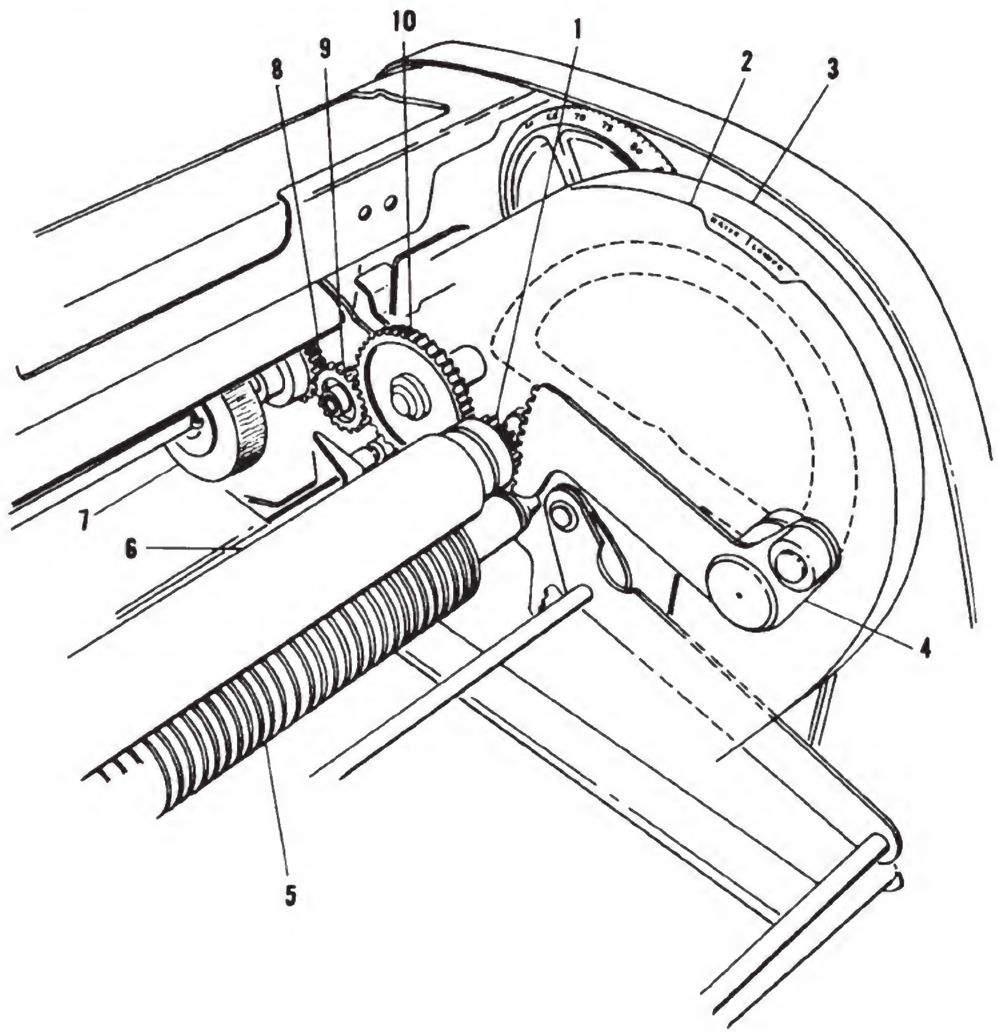
Figure 5-4.—Feed control mechanism.

The lower end of the actuating lever, in contact with the actuating plate pawl, then pivots the actuating plate clockwise. This action disengages the clutch pulley and stops the cylinder in the 11-inch position.

When the selector lever is in the 14-inch position, the selector lever spring LOWERS the pawl on the actuating lever. A stud on the end of this pawl then moves into the path of the LOWER cam follower, whose spring causes the cam to follow the contour of the cylinder cam. As the lower cam follower moves to the high part of the cylinder cam, it causes the clutch pulley to disengage and stop the cylinder in the 14-inch position.

Paper Feeding Mechanism

The paper feeding mechanism for the Model 215 duplicator is illustrated in figure 5-5. When the cylinder of the machine revolves, the cam groove in the raise-lower plate causes oscillation of the moistening roller gear feed segment.



1. Moistening roller gear
2. Cylinder
3. Raise-lower plate
4. Roller gear feed segment
5. Forwarding roller
6. Moistening roller
7. Feed roller
8. Clutch driving gear
9. Idler gear
10. Intermediate gear

91.81X

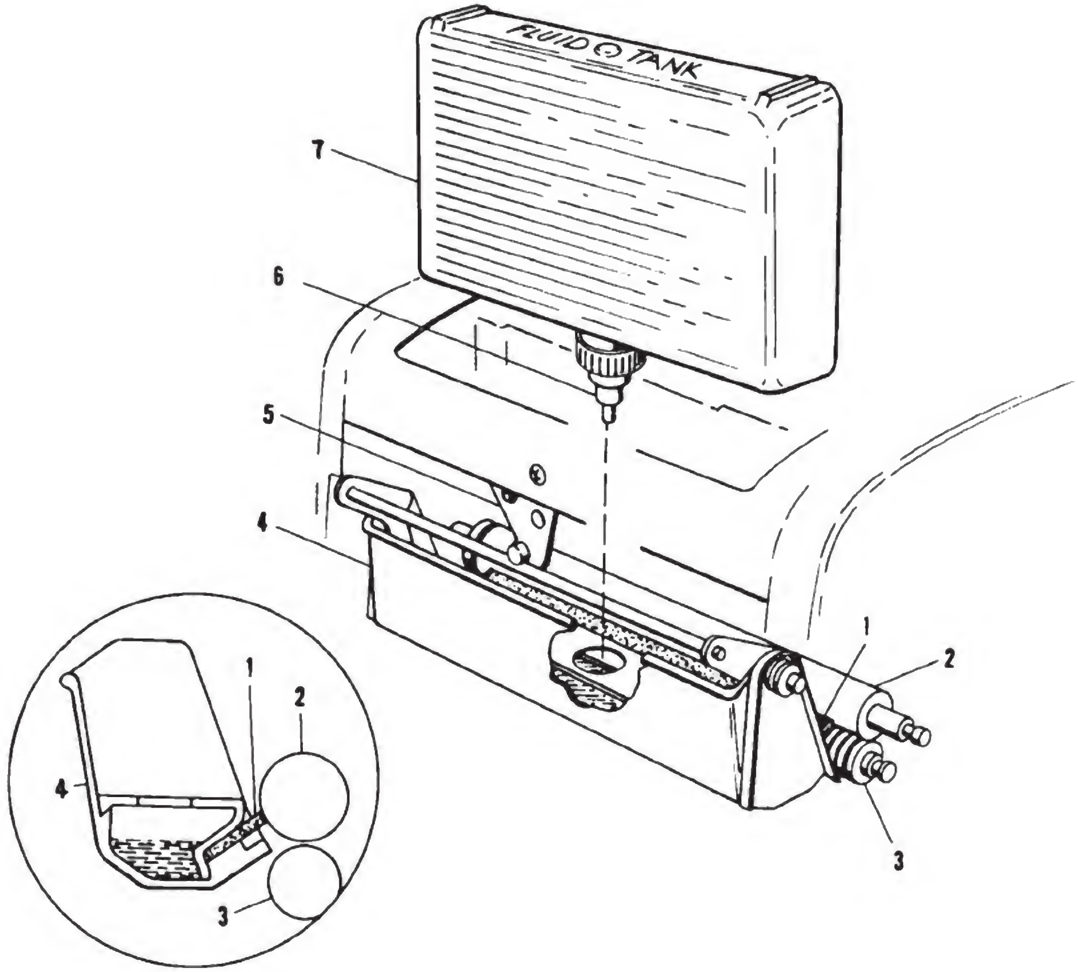
Figure 5-5 .—Paper feed mechanism.

As the truck of the feed segment rides to the HIGH part of the cylinder cam, the feed segment turns the moistening roll gear, the intermediate gear, the idler gear, and the feed shaft clutch drive gear.

When the feed rolls revolve, they advance the top sheet of impression paper to the crotch formed by the moistening roller and the forwarding roller. The clutch assembly allows the feed segment to follow the low contour of the cylinder cam and the feed rolls then FREE WHEEL while the impression paper travels through the machine.

Paper Moistening System

The moistening system of the Model 215 fluid process duplicator consists of the following: fluid container, reservoir assembly, wick, moisture control lever, moistening roller, and the forwarding roller. See figure 5-6.



1. Fluid wick
2. Moistening roller
3. Forwarding roller
4. Fluid reservoir assembly
5. Moisture control (torsion rod) lever
6. Valve cap assembly.
7. Fluid cylinder

91.82X

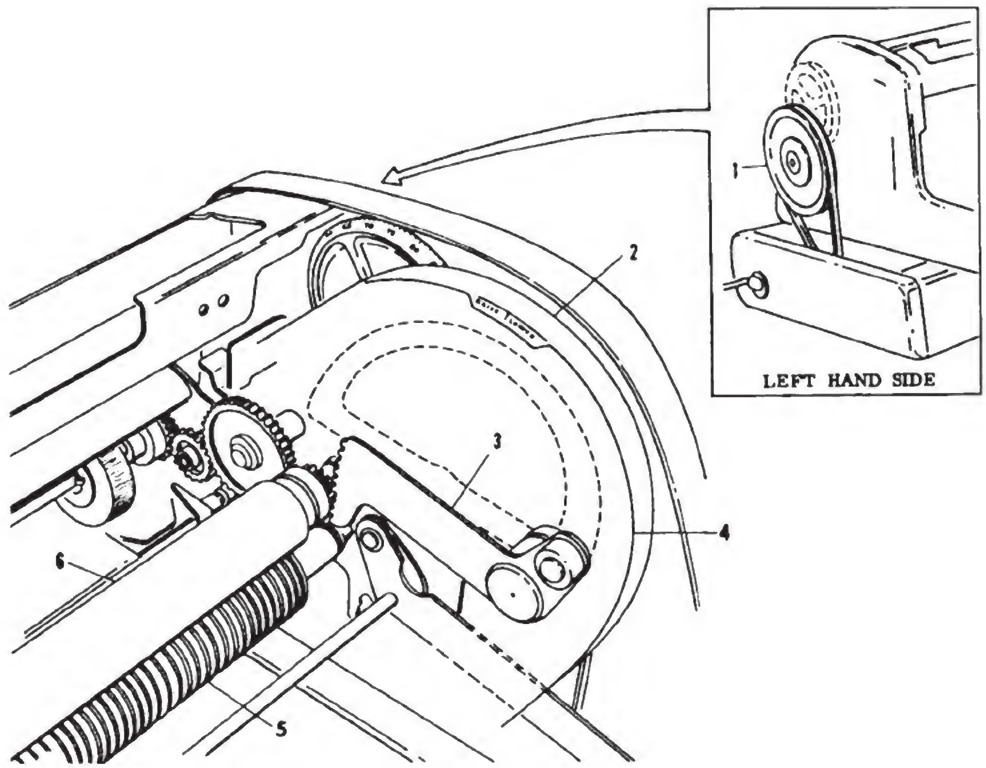
Figure 5-6.—Paper moistening system.

When you invert the fluid container and insert the valve cap in the reservoir, the spring valve is forced open, allowing the fluid to flow into the reservoir until the fluid level reaches the level of the valve outlet. (When the valve outlet is covered, air cannot enter the fluid tank and vacuum prevents further flow of the liquid.)

Now, if you move the moistening control (torsion rod) lever down to the ON position, the saturated wick (insert, fig. 5-6) transfers fluid to the moistening roller, which (in turn) transfers the moistening fluid to the top surface of the impression paper.

Paper Forwarding Mechanism

When the feed rolls advance a sheet of impression paper to the crotch formed by the moistening and forwarding rollers, these rollers forward the paper to the crotch formed by the cylinder and the impression roller. As the cylinder revolves, the cam groove in the raise-lower plate causes the moistening roller gear



1. Clutch assembly
2. Raise-lower plate
3. Moistening roller gear feed segment
4. Cylinder
5. Forwarding roller
6. Moistening roller

91.83X

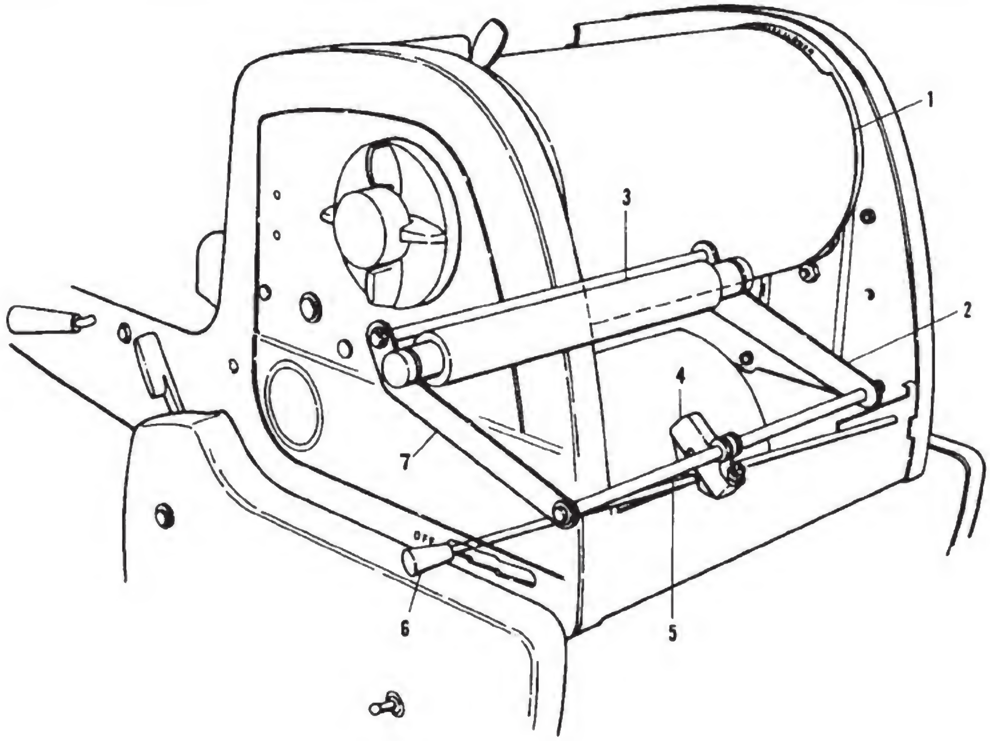
Figure 5-7.—Paper forwarding mechanism.

feed segment to oscillate. As the truck of the feed segment gear rides to the HIGH section of the cylinder cam, the feed segment turns the moistening roller and also the forwarding roller. See figure 5-7.

The clutch assembly allows the feed segment to reverse its movement while the moistening roller continues to revolve during the passage of the impression paper through the machine. The paper, accelerated to cylinder speed by the moistening roller, is now gripped between the cylinder and the impression roller. Under pressure by the impression roller, the moistened surface of the paper accepts a deposit from the master copy, duplicating the master. The duplicated copy is then delivered into the receiving tray.

Impression Roller Pressure Mechanism

Impression roller pressure is controlled by the impression roller pressure control rod, shown in figure 5-8. When the handle of this rod is in the OFF position, toward the front of the machine, impression roller pressure is OFF. If you move the impression roller pressure control rod BACK (through elongated slot in the side frame), the compression link causes the compression link tension bar and the impression roller levers to press the impression roller against the cylinder. When you move the handle of the impression roller pressure control rod FARTHER back, you increase the impression roller pressure against the cylinder.



1. Cylinder
2. Impression roller lever
3. Impression roller
4. Compression link
5. Compression link tension bar
6. Pressure control rod
7. Impression roller lever

91.84X

Figure 5-8.—Impression roller pressure mechanism.

Master Loading Lever

Always stop the cylinder in the 11-inch position when you attach master copies, regardless of the length. When you move the master loading lever (fig. 5-9) to the OPEN position, clamp the cylinder clamp cam upward, as illustrated. This movement of the cylinder clamp cam causes the clamp opening lever to lift the master copy cylinder clamp to the open position to receive the master.

When you move the master loading lever to the CLOSED position, the cylinder cam clamp spring pivots the cylinder clamp cam downward. Then the master clamp springs pull the master clamp DOWN to grip the master copy.

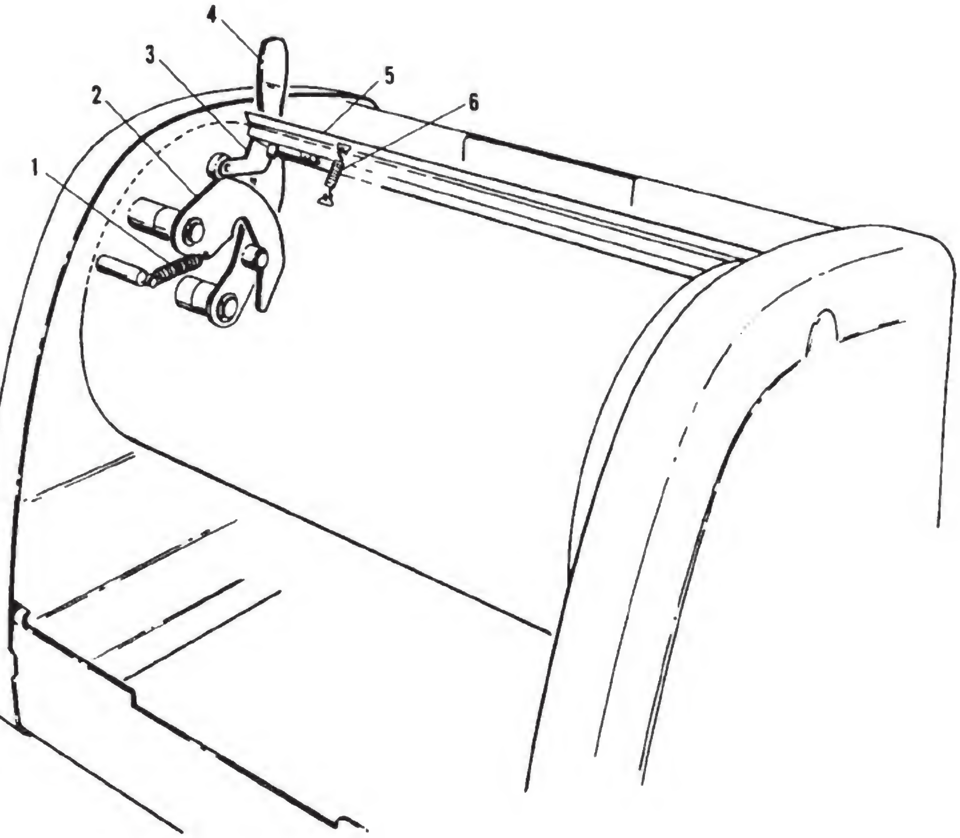
Copy Raise-lower Mechanism

If you turn the raise-lower locking knob (fig. 5-10) counterclockwise, you can turn the cylinder to RAISE or LOWER the copy. When you turn the locking knob clockwise, a cylinder sleeve moves the cylinder to the left, where the cylinder is held firmly in contact with the clutch facing of the raise-lower plate. The adjustment is then locked in the desired position.

DISASSEMBLY AND REASSEMBLY

The manufacturer's technical manual for the A. B. Dick Model 215 duplicator shows how to disassemble the machine in numerical sequence. Small letters are also used to designate the removed parts of some units; and capital letters designate the location of some parts. This system of designating and locating parts of the machine makes disassembly rather simple.

When necessity requires that you dissemble this machine, keep the manufacturer's technical manual available for ready reference.



1. Cylinder clamp cam spring
2. Cylinder clamp cam
3. Clamp opening lever
4. Master loading lever
5. Master copy clamp
6. Master copy clamp spring

91.85X

Figure 5-9.—Master loading lever.

Follow the disassembly procedure by the letters and you will have no difficulty. Use precaution to protect, and prevent the loss of, all parts. Put small parts in containers.

Reassembly procedure is the reverse of disassembly. Clean all parts before you reassemble them; when necessary, install new parts. Check the illustrations in the technical manual for oil points and apply oil during reassembly. Make adjustments to the extent possible as you reassemble parts.

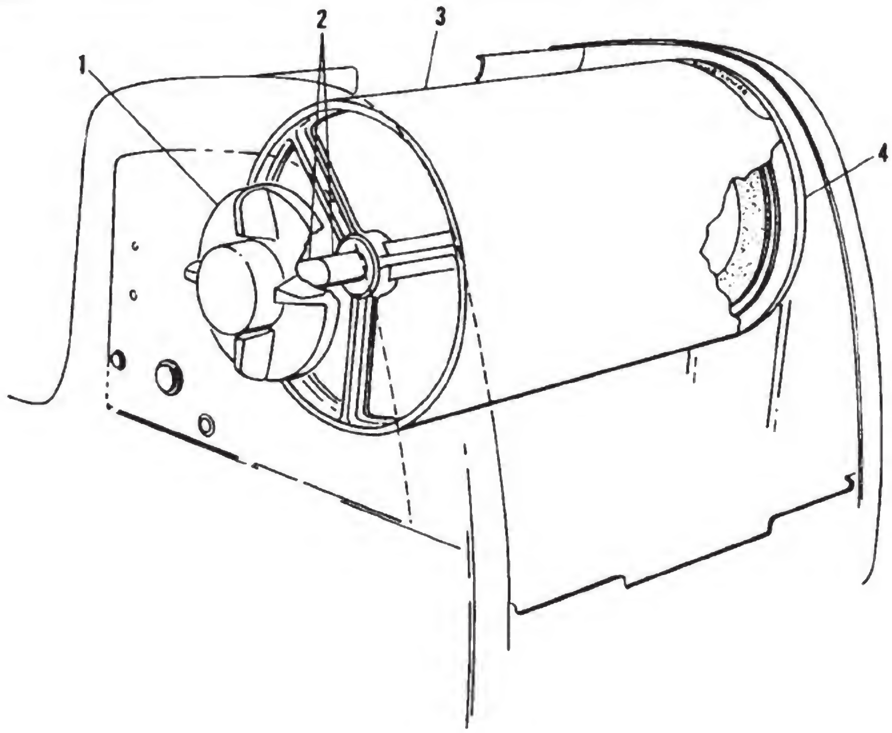
MECHANICAL ADJUSTMENTS

Adjustments of the Model 215 duplicator discussed in this section are those you will be required to make in instrument shops. Read first the procedure for making adjustments on a part or mechanism; then study the illustration to find out where to make them.

Feed Raising Lever

Adjust the feed raising lever as necessary to have it lift the feed rolls to the proper height for loading impression paper on the feed table. To do this, proceed as follows:

1. Lower the feed roll assembly to the feeding position (fig. 5-11).
2. Turn the separator lever down to the loading position in order to have it lock in the notch of the feed raising lever.



1. Raise-lower locking knob
2. Cylinder sleeve
3. Cylinder
4. Raise-lower plate

91.86X

Figure 5-10.—Copy raise-lower mechanism.

3. Loosen the hexagonal nut which holds the lever and bracket assembly in place and adjust the feed raising lever to the extent required to have the underside of the bracket 15/16" above the bare feed table, as illustrated.

4. Tighten the hexagonal nut.

Feed Roll Pressure

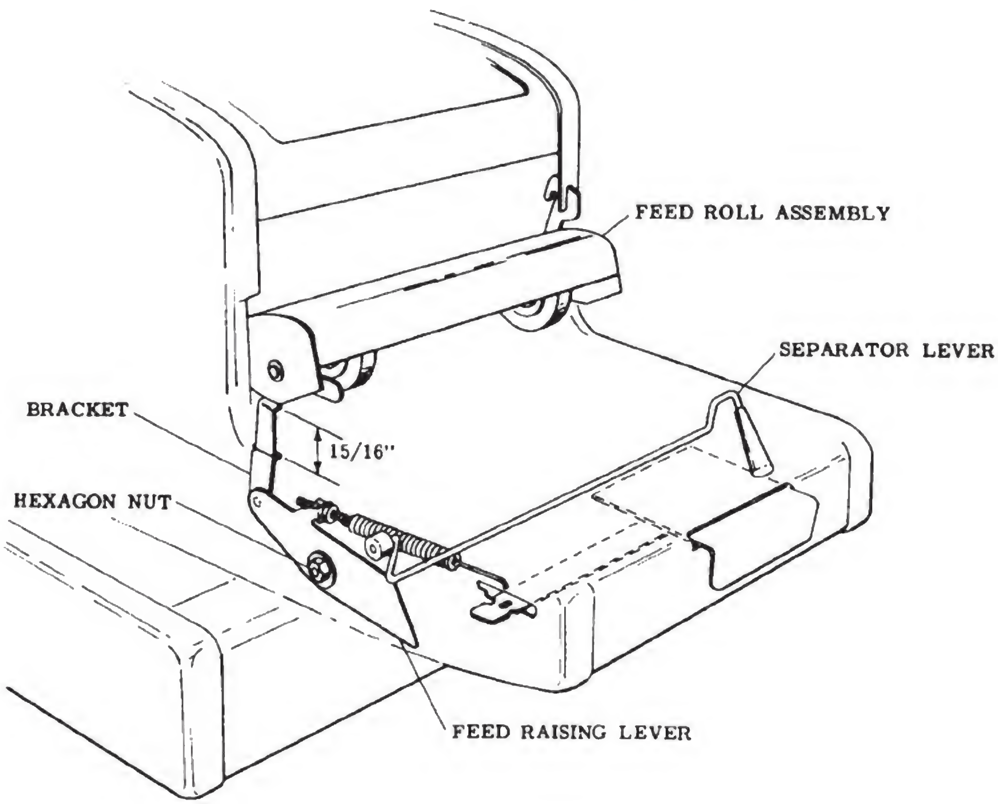
Pressure on the feed rolls is correct when feeding of paper into the machine is ACCURATE. (Pressure control spring is properly adjusted.) To adjust the pressure control spring, do the following:

1. Put the pressure control lever in the LOW position. See figure 5-12.
2. Place a 7/16" block on the feed table under the lip of the bracket, as illustrated.
3. Put a spring tension testing scale on top of the bracket secured to the pressure control lever and press DOWN. If the reading on the pressure scale is NOT 21 ounces, turn the nuts on the adjusting screw to the extent necessary to make the reading 21 ounces.

Feed Rolls

To ensure the feeding of each sheet of paper STRAIGHT INTO the machine, the feed rolls must be adjusted PARALLEL WITH the feed table. To adjust them in this manner, proceed as follows:

1. Assemble each feed roll (with friction spring) on the same flat surface of the square shaft, with the black dot on the roll facing the left side of the machine (fig. 5-13).
2. Position the paper guide rails for 8 1/2" paper.
3. Lower the feed rolls and center each roll over the cork pad on the guide rail. Study the illustration.
4. Put the pressure control lever in the LOW position.
5. Place a strip of paper between each feed roll and the cork pad and pull on the strips. If the pull on both strips is NOT EQUAL, turn the adjusting screw (illustrated) as necessary to equalize the roll pressure.



91.87X

Figure 5-11.—Adjusting the feed raising lever.

Wick Alignment

In order to ensure uniform quality in copying, the wick of the duplicator must contact the moistening roll in a uniform manner along its entire length. In order to get uniform pressure of the whole wick on the surface of the moistening roll, do the following:

1. At each end of the moistening roller, put a 1-inch strip of 20 lb. paper between the DRY wick and the roller. Study figure 5-14.
2. Push the torsion rod down to the ON position to apply pressure on the wick and then test the PULL on each strip of paper.
3. If necessary, bend the trough bracket where the resistance to your pull is LESS. Bend the lower end of the bracket toward the moistening roller. CAUTION: Use care; a SLIGHT bend is sufficient.

Impression Roller Pressure

Pressure on the impression roller must be such that proper pressure can be obtained at minimum and maximum settings. To obtain correct impression roller pressure, proceed as follows:

1. Put the impression roller control rod in the OFF position.
2. Loosen the lock nut (fig. 5-15) and turn the adjusting screw until a slight drag takes place between the impression roller and the cylinder. Test the drag by turning the roller in the direction indicated by the arrow.
3. Hold the adjusting screw and tighten the lock nut. Then recheck the drag on the impression roller.

Clutch Actuating Cam

The clutch actuating cam is properly adjusted when it stops the cylinder with the master copy clamp in the desired position for attaching and removing master copies. You can properly adjust the cam by:

1. Positioning the cylinder raise-lower adjustment exactly at the 0 position. See illustration 5-16.
2. Placing the impression roller control rod in the medium pressure position.

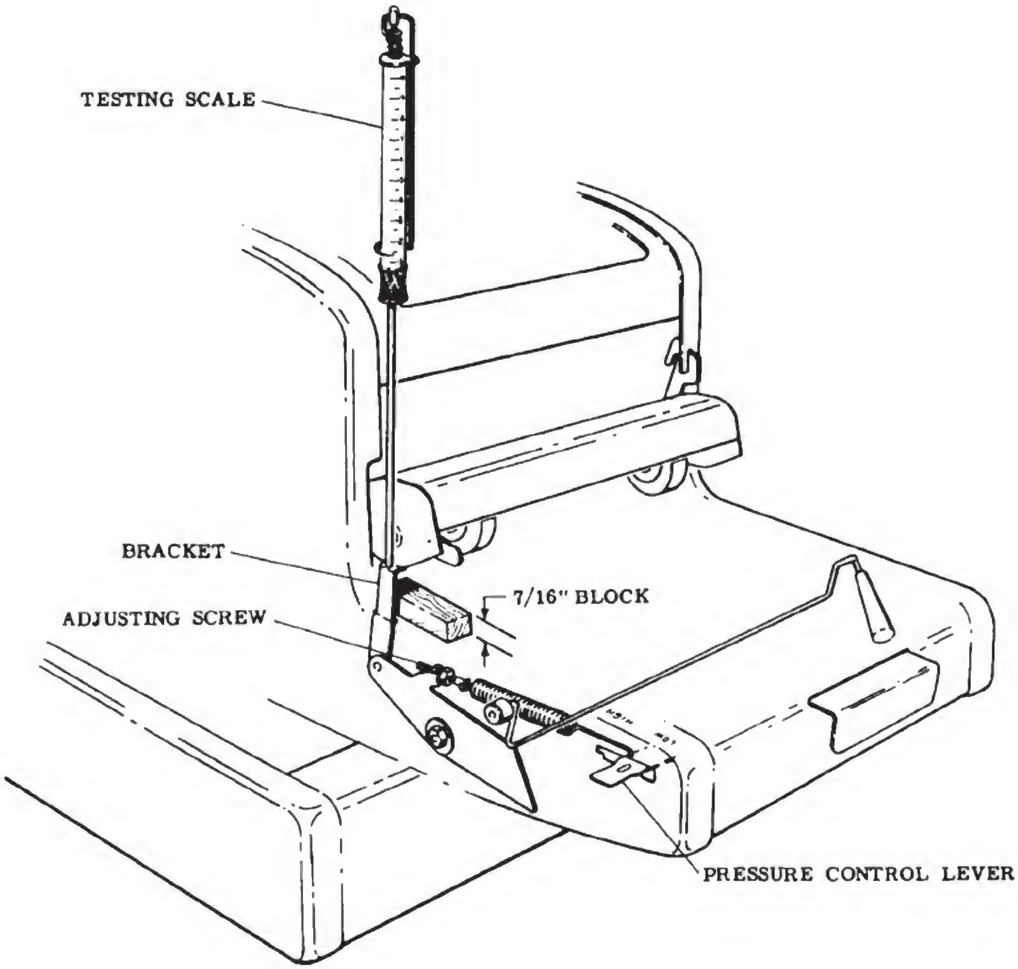


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Figure 5-12.—Adjusting feed roll pressure.

3. Putting the selector lever in the 11-inch position, turning on the motor switch, pressing the cycling lever and allowing the cylinder to stop and turn off the motor.
4. Setting the counter dial at 0, as shown.
5. Placing the BEVELED EDGE of the cylinder at the master clamp in line with figures 94-95 on the counter dial.
6. Pressing the cycling lever, loosening the adjustment screw on the cam, and rotating the cam in the opposite direction from the movement desired of the cylinder. NOTE: Counterclockwise rotation increases the dimension; clockwise rotation decreases the dimension.
7. When you have the adjustment correct, tighten the screws and recheck.

Cycling Mechanism

The cycling mechanism is properly adjusted when it functions satisfactorily in BOTH the single-sheet and continuous-feed positions. To make proper adjustments, do the following:

1. Loosen screws A and B (fig. 5-17).
2. Position the end of the actuating lever on the step of the pawl, as illustrated.
3. Locate the truck (roller) of the extension lever in the CENTER position of the cycling lever cam.
4. Adjust the actuating lever as necessary to have the formed ear rest on the pawl.
5. Tighten screw A and position the cycling lever as shown in the insert of figure 5-17. Note the position of the 23/32" dimension.

Drive Belt

The drive belt is correctly adjusted when it has 1/4" of slack, as shown in figure 5-18. You can properly adjust the belt by:

1. Loosening the four mounting screws and positioning the motor in the position required to have the correct amount of slack in the belt.
2. Tightening the mounting screws and checking the adjustment.

When the drive belt is adjusted properly, one side of it moves 1/4" without causing any movement in the opposite side of the belt or motor pulley.

LUBRICATION

The A. B. Dick Model 215 duplicator is lubricated at the factory with special lubricants and will run for years under normal operating conditions without additional lubrication. If it is necessary during repairing or overhauling of the machine that you wash parts with solvent or immerse the machine in solvents for cleaning, however, oil all parts which require oil with factory-recommended lubricants. Check for the location of oil points on illustrations in the technical manual for the machine.

The accompanying chart lists the parts of the duplicator which require lubrication and

LUBRICATION CHART

Name of Part	Lubrication Procedure
1. Cylinder drive gear	Grease the cam and brush grease into all gear teeth.
2. Upper and lower cam followers	Grease the frame studs and oil the trucks and rivets.
3. Actuating lever	Grease the frame stud and the latch.
4. Release lever	Grease the frame stud and oil the truck and rivet.
5. Cycling lever	Grease both ends of the shaft and the cam surface.
6. Selector lever	Grease both frame screws and the extension.
7. Clutch pulley	Grease the pulley shaft. CAUTION: Do NOT oil or grease the internal assembly of clutch 7A, or the brake facings of the actuating plate.
8. Counter	Grease the mounting screw, and brush grease into all teeth of the counter ratchet.
9. Counter lever	Grease the counter lever at the contact point with the raise-lower cam and at the lower end.
10. Feed roll shaft and gear	Grease both ends of the shaft, and brush grease into the gear teeth.
10A. Feed roll clutch	Apply a FILM of oil to the teeth of the clutch housing. Do NOT oil the teeth.
11. Large idler gear	Grease the mounting stud, and brush grease into the gear teeth.
11A. Small idler gear	Same as for large idler gear.
12. Feed roll cradle	Grease both cradle studs.
13. Gear segment	Grease the segment shaft, the gear teeth, and the cam slot. Oil the truck and rivet.
14. Moistening roller	Grease both ends of the shaft.
14A. Moistening roller/clutch	Apply a FILM of oil to the teeth of the clutch housing. Do NOT over oil the teeth.
15. Forwarding roll	Grease both shaft bearings.
16. Cylinder shaft	Grease both shaft bearings.
17. Impression roller and pressure control rod	Grease the rod at both ends and at the center contact with the compression link.
18. Master loading lever	Grease the lever stud and oil the truck and rivet.
19. Master loading cam lever	Grease the cam surface and the stud.
20. Impression roller	Oil the shaft ends in the roller bearings.
21. Motor	Lubricate the bearings each month with 3 or 4 drops of S.A.E. #20 oil. If usage is heavy, oil more frequently.

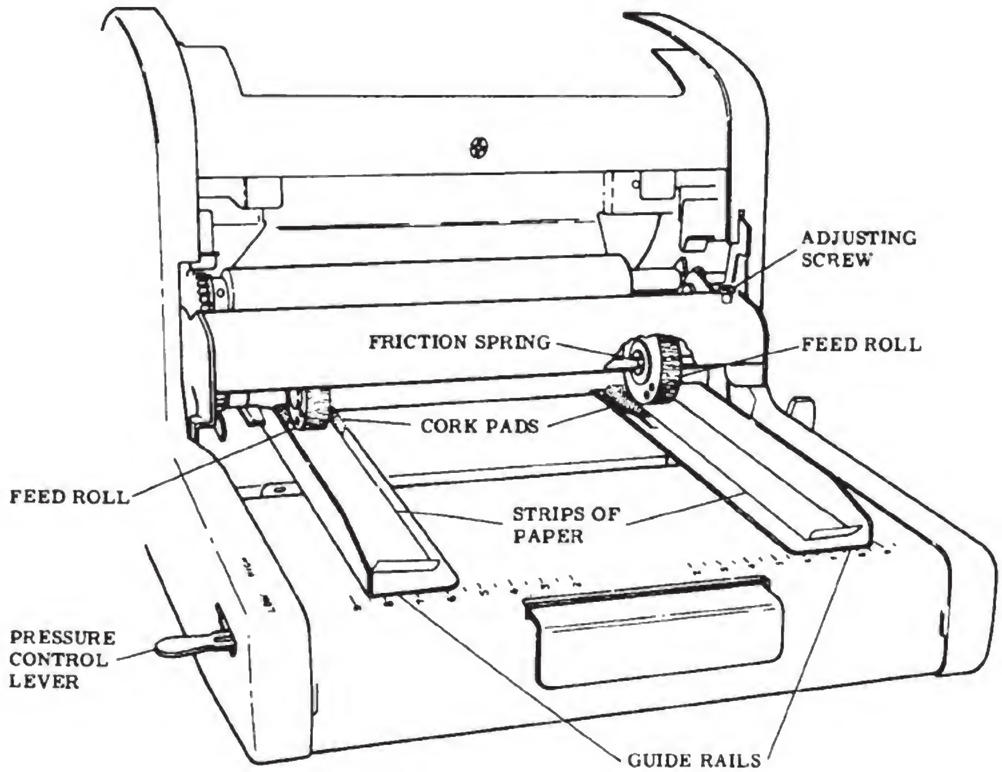

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Figure 5-13.—Adjustment of feed rolls.

gives the recommended procedure for lubricating. Each part is numbered, and each part is indicated by the same number used in the chart.

ADDRESSOGRAPHS

Addressographs are widely used throughout the Navy for simplifying and speeding up routine office work—addressing envelopes, and preparing pay rolls, purchase lists, and inventories (supply). These machines are useful for reprinting the same information, of which a circular letter is a good example.

When embossed plates are put in an Addressograph, the machine prints all the information on a single plate with one stroke (manually or electrically operated). Information on these plates may be: names and addresses, service or payroll numbers, or other essential data.

Addressographs are grouped in classes in accordance with similarities of construction and operation. Machines within each group or class are designated as MODELS. Some of the different classes are:

1. CLASS 100, which holds only one address plate, inserted and removed manually before and after each printing.
2. CLASS 200, which is discussed in detail in this chapter.
3. CLASS 500, the simplest Addressograph, which holds only one plate at a time and is used primarily for proofing new plates as they come from the graphotype.
4. CLASS 700, which is still in use by the Navy but which is being replaced by CLASS 200.
5. CLASS 900, which is discussed in some detail in this chapter.
6. CLASS 1900, an improved type of Addressograph, discussed in some detail in this chapter.
7. CLASS 5000, newest and best Addressograph (with electronic ·controls), discussed briefly in this chapter.

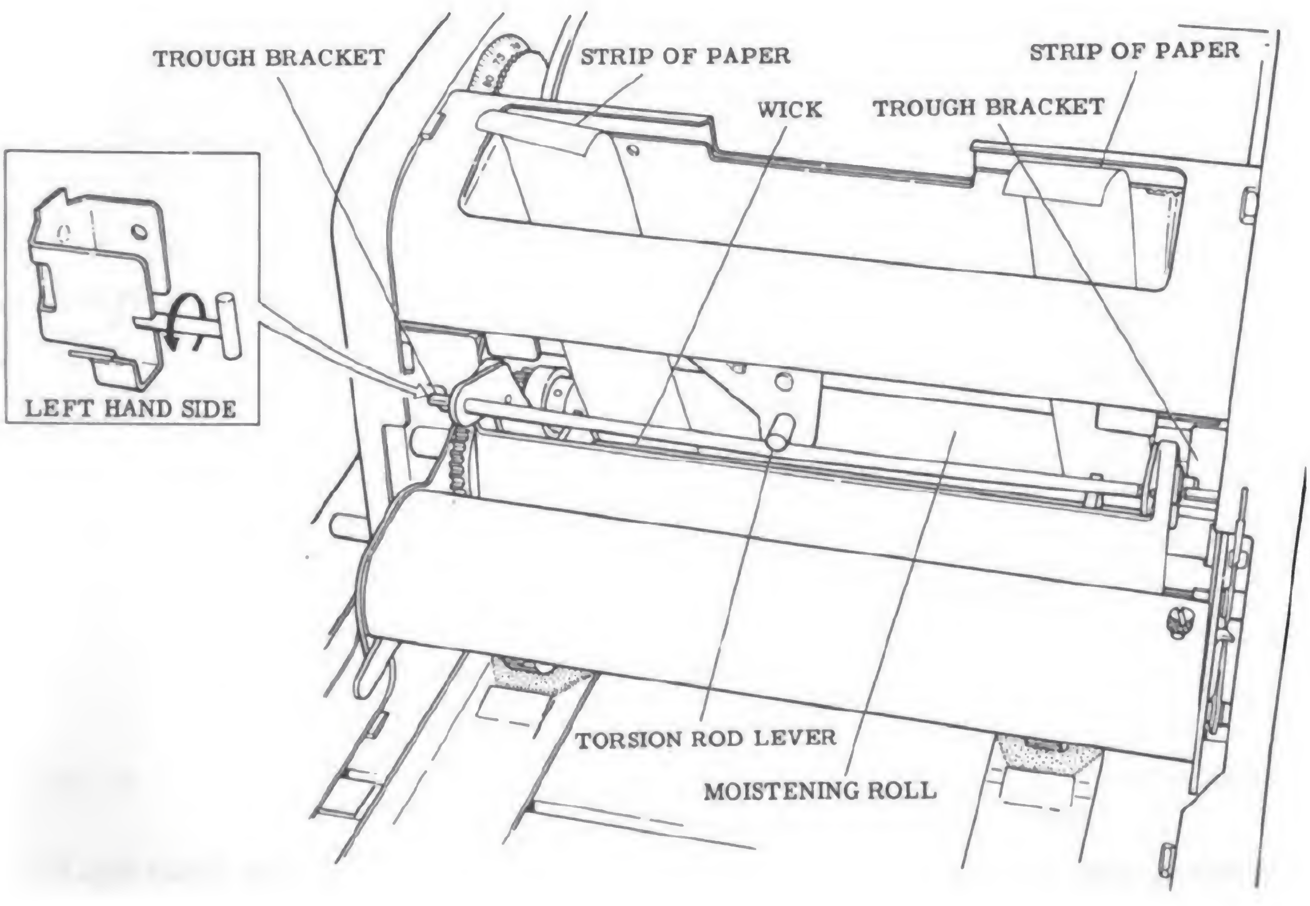

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Figure 5-14.—Wick alignment.

CLASS 200 ADDRESSOGRAPH

A Class 200 Addressograph is shown in figure 5-19. It is a hand-operated machine which is used rather extensively by the Navy. The embossed plates are placed in the magazine, face up, and with the index card toward the rear of the machine. Plates may be identified by the index card or by the tabs which are visible when the plates are in printing position. Some of the parts and mechanisms of this Addressograph are explained next.

Skipper

The skipper (fig. 5-20) of the Class 200 machine is used TO ADVANCE the first plate from the magazine to printing position, and also to SKIP plates past the printing position (without making an impression). The operator of the machine can skip plates by pressing the skipper lever, as shown, and by bringing the platen head down against the bed of the machine.

Selector Lever

The selector lever (fig. 5-21) on the Class 200 machine operates the mechanism which enables the operator to make any number of impressions from one plate. When the selector lever is placed in the REPEAT position, for example, with the plate at PRINTING position, the plate remains in this position until the position of the lever is changed to the CONSECUTIVE spot.

Counter

A counter, shown in figure 5-21, visually registers the number of imprints made by an

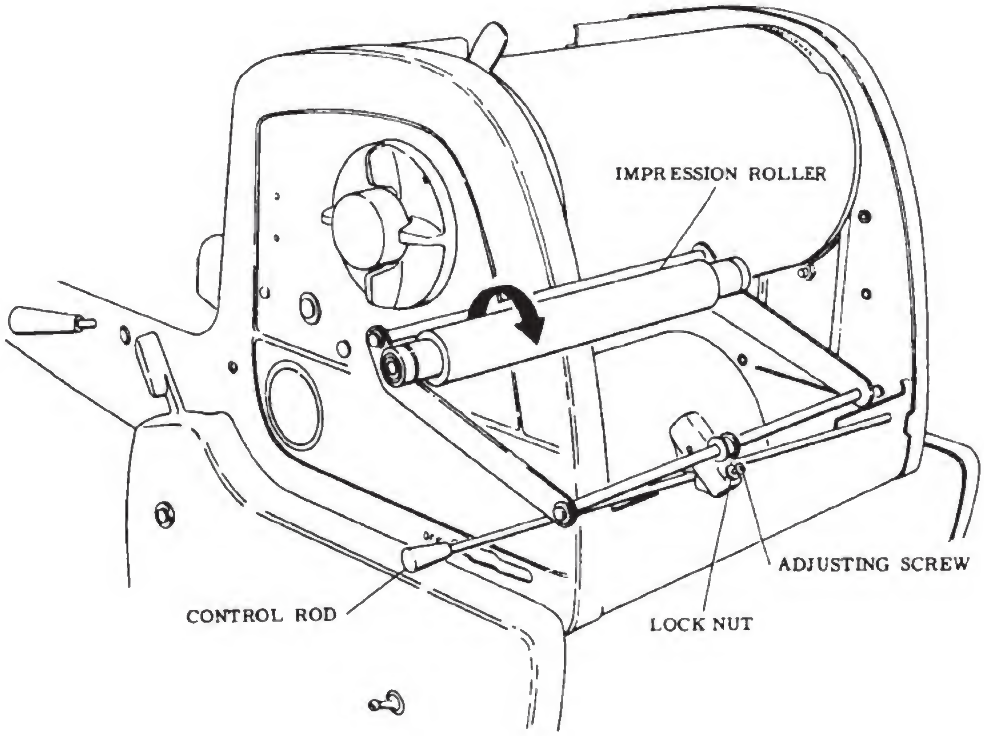

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Figure 5-15.—Adjustment of impression roller pressure.

Addressograph from 1 to 99999. It does NOT register plates skipped through the machine, and the counter RESET knob is LOCKED when the platen head is in the UP position to prevent accidental resetting of the counter back to zero.

To reset the counter, move the platen head down against the bed of the machine and turn the reset knob COUNTERCLOCKWISE until the counter registers 99999. Then raise the platen head to the UP position to advance the counter wheels to zero.

Cut-Off

The function of a cut-off on an Addressograph is to prevent the printing of a portion of the information embossed on a plate. Study figure 5-22 carefully. The cut-off consists of a platen with part of the rubber cut away, and a ribbon guard with the opening so cut that it covers the corresponding portion of the plate. Observe the curved dotted lines between the platen and the plate in figure 5-22.

The procedure for installing a cut-off on an Addressograph follows:

1. Press down on the platen handle (fig. 5-22) and then slide the standard platen off the left side of the platen head, as indicated by arrows in the illustration.
2. Install the cut-off platen by engaging the right end of the channel along the top of the platen over the left end of the track (on bottom of platen head).
3. Remove the ribbon guard on the machine by lifting the left side of the guard enough for the retaining tab (illustrated) on the guard to clear the retaining hole in the machine and by sliding the guard to the left, off the machine.
4. Install the cut-off ribbon guard by inserting the edges of the guard in the rear and forward channels in the table top and then by sliding it to the right until the retaining tab on the guard snaps into the hole in the table top.

Daters

The function of daters on Addressographs is to print desired information to the right (right and left on double daters) of the address plate impression, or within the printing area of the

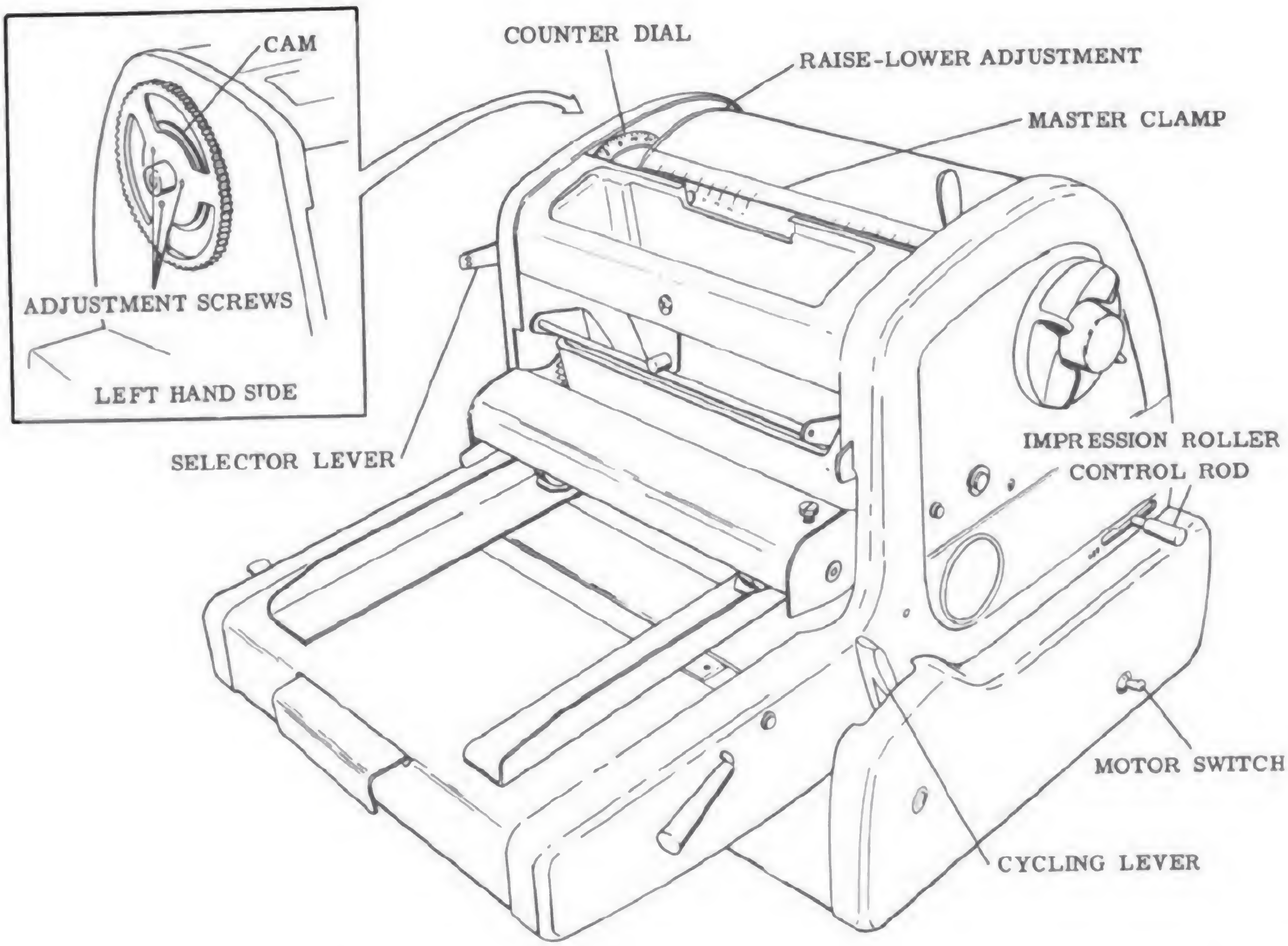

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Figure 5-16.—Adjustment of clutch actuating cam.

address plate. There are two types of regular daters, RIGHT and OVERHEAD. A dater (right) is shown in figure 5-23. It is given this name because it prints information to the RIGHT of the address plate impression. You can install a dater (right) in the following manner:

1. Remove the ribbon guard and expose the dater by lifting the ribbon.
2. Insert the top edge of the dater plate under the rear retaining lip. Then push the dater plate toward the rear of the machine until the front edge of the plate can be placed under the FRONT retaining lip. Study the illustration.
3. Turn the ribbon spool with the crank to remove slack from the ribbon and replace the ribbon guard.

An OVERHEAD dater (fig. 5-24) consists of an embossed dater plate secured to the ribbon support, as illustrated. The position of the dater plate coincides with a cut-out portion of the address plate as it is held at the printing position.

The procedure for installing an overhead dater is as follows:

1. Lift the ribbon to expose the ribbon support and insert the dater plate under the retaining clips and push it rearward until the latch pin enters the hole in the dater plate.
2. Remove slack from the ribbon by turning the ribbon spool with the crank and the operation is complete.

Lister Mechanism

A lister, shown in figure 5-25, is used to list impressions on ruled or unruled paper. Spacing between impressions is adjustable, and one

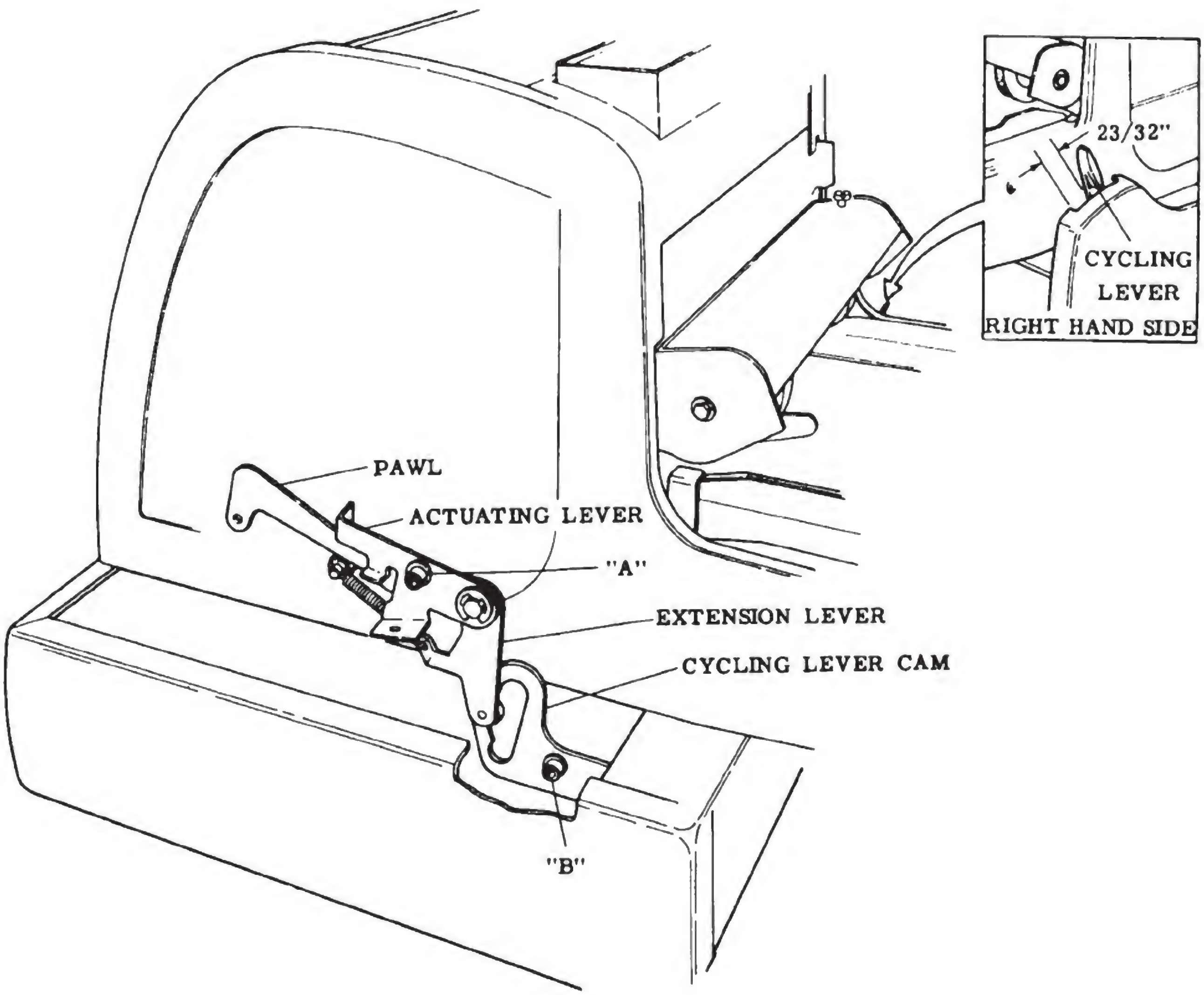

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Figure 5-17.—Adjustment of cycling mechanism.

line or a full plate impression may be listed. To operate the lister, push the feed roller control rod IN.

Note the lister crank in the circle in figure 5-25. It is used to increase or decrease spacing in the lister. Turn CLOCKWISE to increase spacing and COUNTERCLOCKWISE to decrease spacing.

Ejector Mechanism

An ejector automatically ejects cards or envelopes from an Addressograph after they have been imprinted. Study illustration 5-26, which shows the ejector mechanism on a machine. Observe all parts, and the nomenclature.

The ejector arm is secured by a bushing to the impression arm; and as the impression arm is operated, it operates the ejector arm attached to the mechanism which operates the ejector foot. When the ejector foot snaps to the left, it ejects the envelopes or cards into a receiving hopper at the left of the machine. Attaching an ejector is a simple operation.

If the Addressograph has a lister, remove the cover plate and so locate the end of the ejector arm that the drive pin in the impression arm is through the hole in the bushing. Tighten the mounting screw. Then place an envelope or

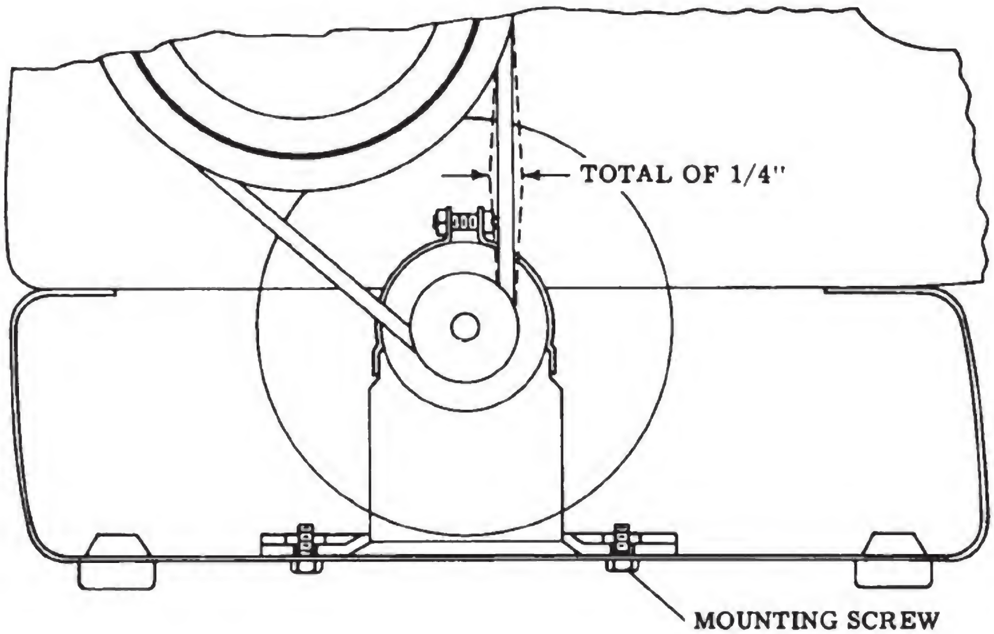

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Figure 5-18.—Adjustment of the drive belt.

form on the machine in proper position for printing, loosen the lock nut and set the ejector foot to JUST TOUCH the right edge of the envelope, and line up the rear gage with the rear edge of the envelope.

Ribbon Mechanism

The ribbon cover mechanism for the Class 200 Addressograph is illustrated in figure 5-27. Note the position of the core retainer, locking tube in the retainer, the ribbon core driver, and the core retainer spring.

A properly inked ribbon is essential; otherwise, impressions are not distinct and even. If the impressions become too light, install a new ribbon. To do this, proceed as follows:

1. Remove the ribbon guard and insert the ribbon crank in the hole to the left of the discharge hopper and wind the ribbon onto the left ribbon spool.
2. Remove both ribbon guide pins and disconnect the right end of the ribbon. Raise the ribbon clip to disconnect the ribbon.
3. Push the core retainer of the left ribbon spool toward the rear of the machine and lift the ribbon and core out.
4. Unroll about 12" of ribbon from the new ribbon spool and put the new ribbon on the core. Then put the core and ribbon back in the machine. Be sure the locking tube in the ribbon core is in the slot in the driver.
5. Connect the right end of the ribbon to the right spool and replace the ribbon guide pins UNDER THE RIBBON. Be sure the ribbon is in the LOWER portion of both ribbon guide pins. Turn the ribbon spool clockwise to remove slack.

Platen Adjustments

Impressions made by the platen must be uniform. If impressions are TOO HEAVY on one side or on the top or bottom lines, make adjustments in the manner explained in the following paragraphs. Refer to figure 5-28 as you study the procedure.

1. IMPRESSION ON LEFT SIDE TOO HEAVY.—To correct this condition, turn the right adjusting screw 1/4 turn counterclockwise and the left adjusting screw 1/4 turn clockwise. Check the impression and, if necessary, repeat the adjustment.
2. IMPRESSION ON RIGHT SIDE TOO HEAVY.—This condition can be eliminated by turning the left adjusting screw 1/4 turn counterclockwise and the right adjusting screw 1/4 turn clockwise. Test the impression.

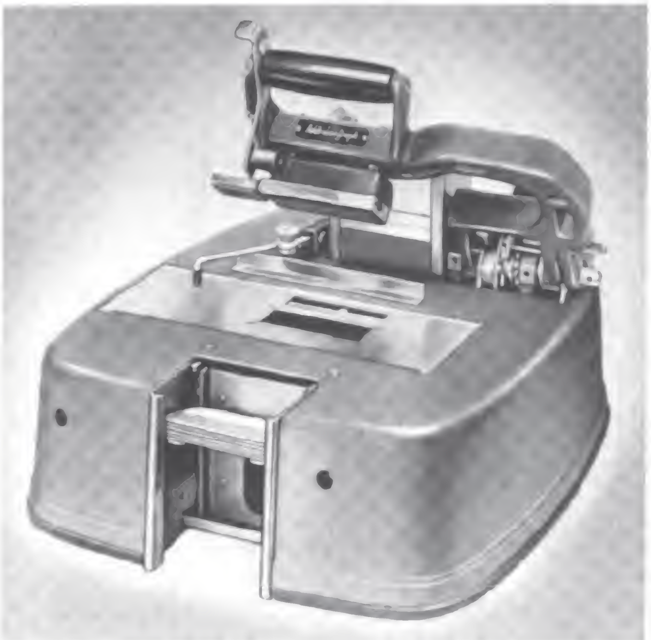

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Figure 5-19.—Class 200 Addressograph.

3. IMPRESSION OF TOP LINES TOO HEAVY.—You can correct this trouble by: (a) loosening the lock nut between the impression arm and the platen head and also the center locking screw, and (b) turning both adjusting screws 1/4 turn clockwise. Tighten the center locking screw and lock it. Then check the impression.

4. IMPRESSION OF BOTTOM LINES TOO HEAVY.—When the impression of the bottom lines on a plate are too heavy, make the following adjustments: (a) loosen the lock nut between the impression arm and the platen head and also the center locking screw, (b) turn both adjusting screws 1/4 turn counterclockwise, and (c) tighten and lock center locking screw and test the impression. If necessary, make further adjustments.

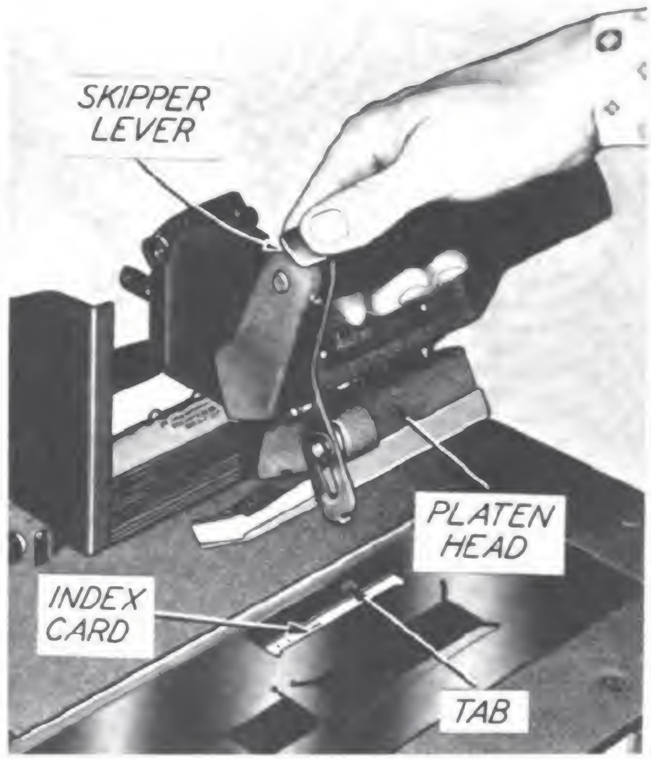

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Figure 5-20.—Operating the skipper.

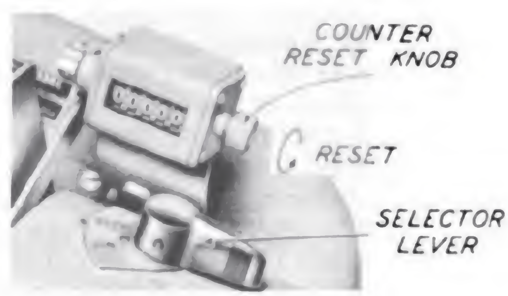

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Figure 5-21.—The counter.

CLASS 900 ADDRESSOGRAPH

The Class 900 Addressograph is equipped with a motor which operates on either alternating (AC) or direct (DC) current. Study figure 5-29, which shows a table model of the Class 900 machine.

The control keys (REPEAT, CONS, AND SKIP) of the Class 900 Addressograph are on the top of the control panel and the switch is on the bottom, as indicated. The stand model has a foot trip pedal for controlling consecutive operation.

The platen of the Class 900 machine is a rubber-faced cylinder, which ROLLS ACROSS the embossed plates to make impressions.

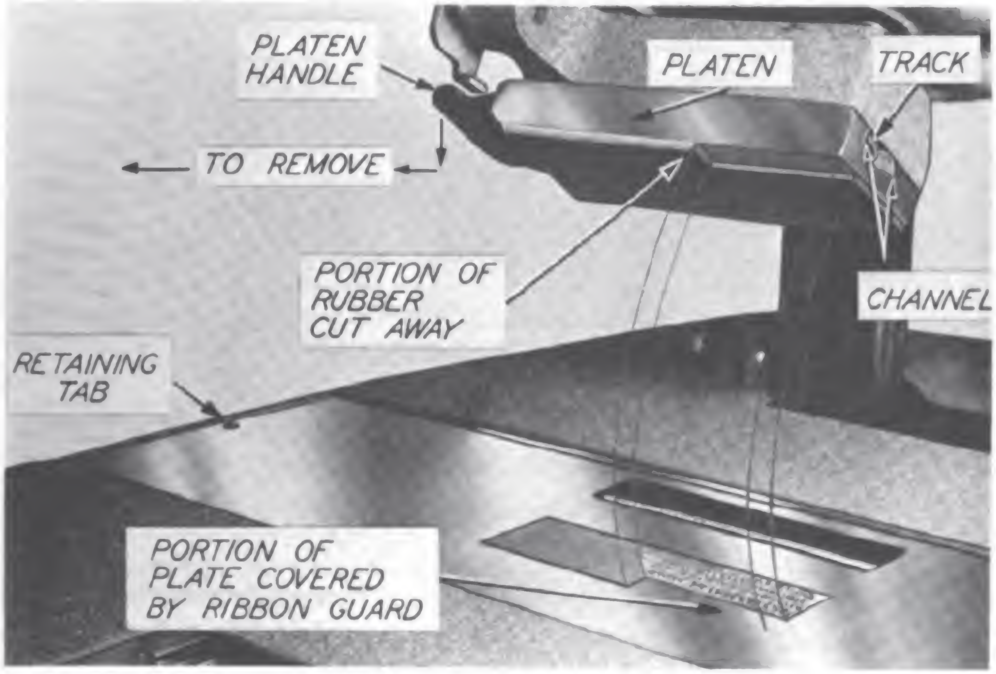

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Figure 5-22.—The cut-off.

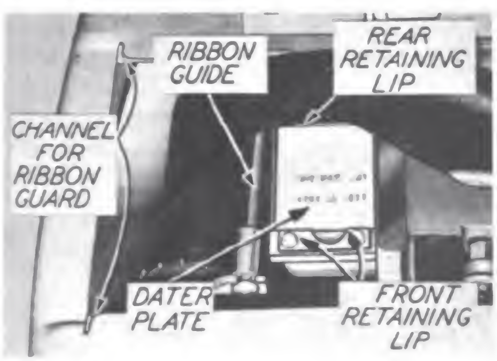

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Figure 5-23.—Dater (right).

Precaution must always be taken with an Addressograph to prevent jamming of plates and overheating or burning out of the motor. To prevent either of these conditions from occurring, the manufacturer has installed a friction clutch in the table model of the Class 900 machine. When properly adjusted, the clutch allows slippage to prevent overheating of the motor when jamming of plates occurs. The motor of the stand model, however, does not have a friction clutch. Power is transmitted from the motor to the machine by belts and pulleys; and when tension on the belts is correct, they allow slippage when a plate jams.

Disassembly Procedure

As you study the procedure for disassembling a Class 900 Addressograph, refer to figure 5-30, which gives the nomenclature of many parts of the machine and shows their location. Proceed as follows:

1. Remove covers from the machine.
2. Slide the ribbon guard forward enough to free it from its position pins and then lift it off.
3. Wind the ribbon onto the left-hand spool and release the left spool. Then partially unscrew the screws which secure the ribbon guides on each side of the machine and remove the guides.
4. Remove caps at the end of the platen arms and disconnect the springs from the two platen latches; then remove the C-washers and take off the latches.
5. Remove the drive link springs at the rear of the drive link and drive arms (fig. 5-31) and slide the platen forward off its rails.
6. Remove the screws from each track assembly and then remove the tracks.

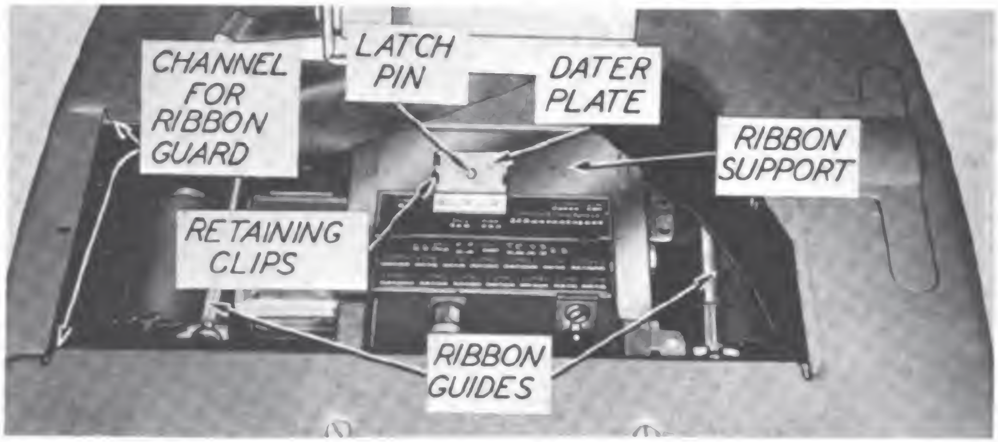

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Figure 5-24.—Dater (overhead).

7. Tilt the machine (fig. 5-32) and disconnect the motor wires from the switch. Then loosen the setscrews and nuts and remove the motor.

8. Remove tapered pins which hold the ribbon drive shaft and slide the shaft to the left through the hole in the side of the bed.

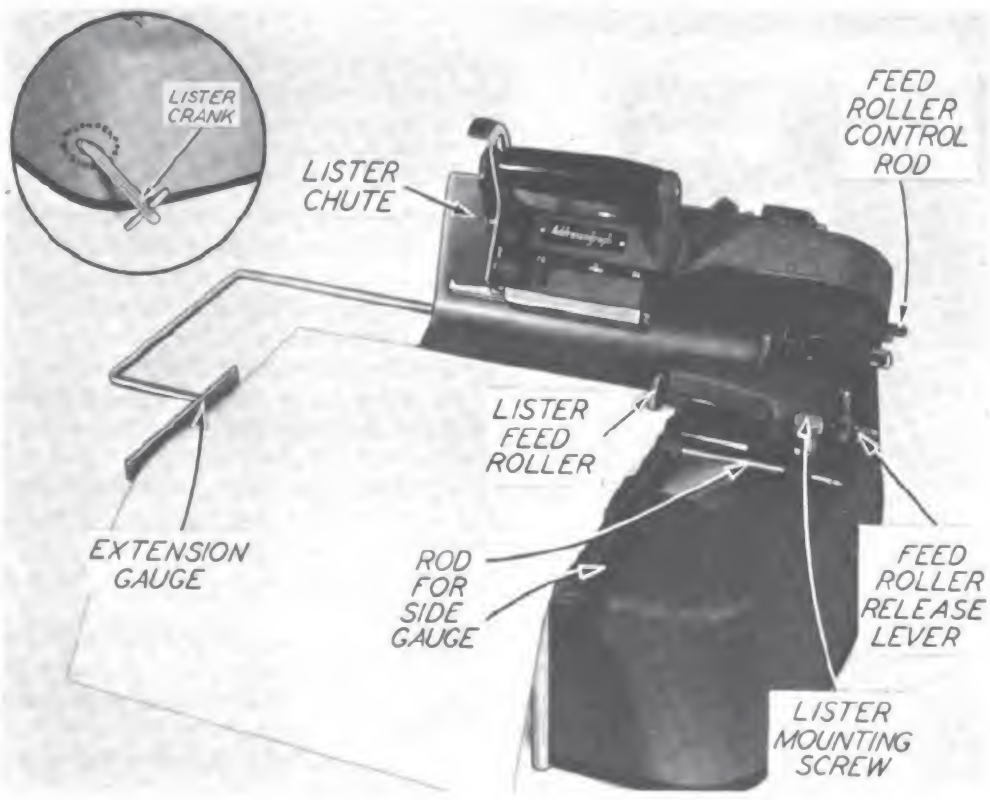

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Figure 5-25.—Lister.

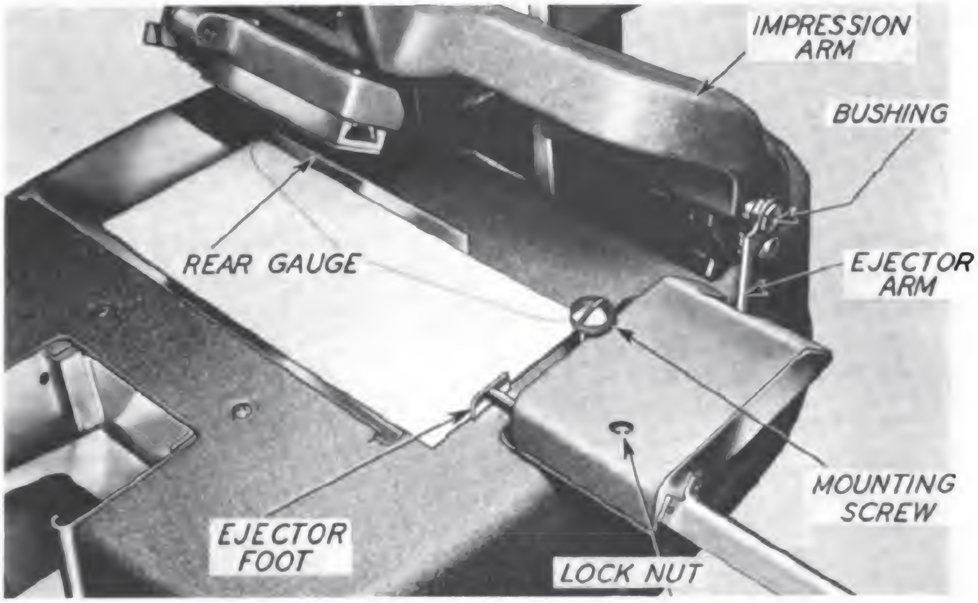

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Figure 5-26.—Ejector mechanism.

9. Remove the platen drive rod by loosening the lock nuts which secure it, turning the eccentric to its farthest throw, removing adjusting screws, and rotating the drive rod counterclockwise to free it from the eccentric and drive arms.

10. Loosen the lock nuts which secure the adjusting stud and rotate the stud counterclockwise to free it from the eccentric and drive arms.

11. Remove C-washers from the drive rocker assembly shaft and slide the shaft out of the machine.

12. Slide the carrier bars and drive link assembly forward; then pull the carrier bars down and out of the machine (through bottom).

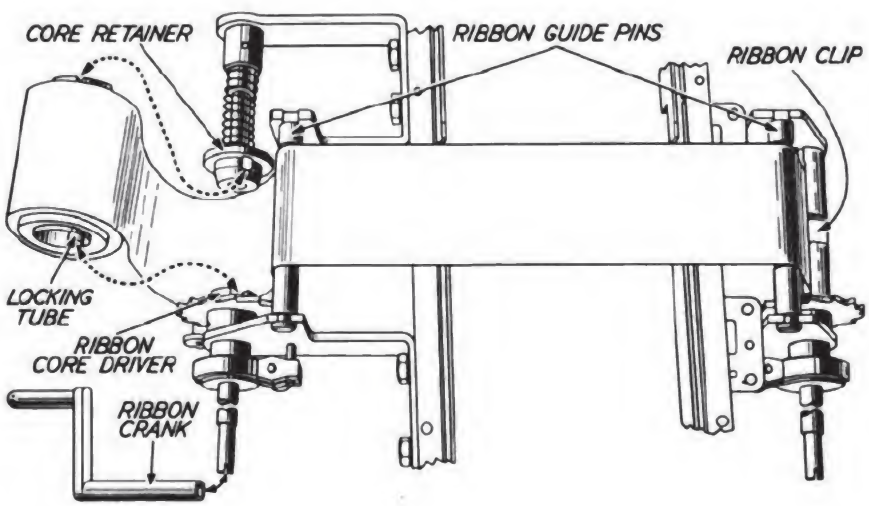

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Figure 5-27.—Ribbon mechanism.

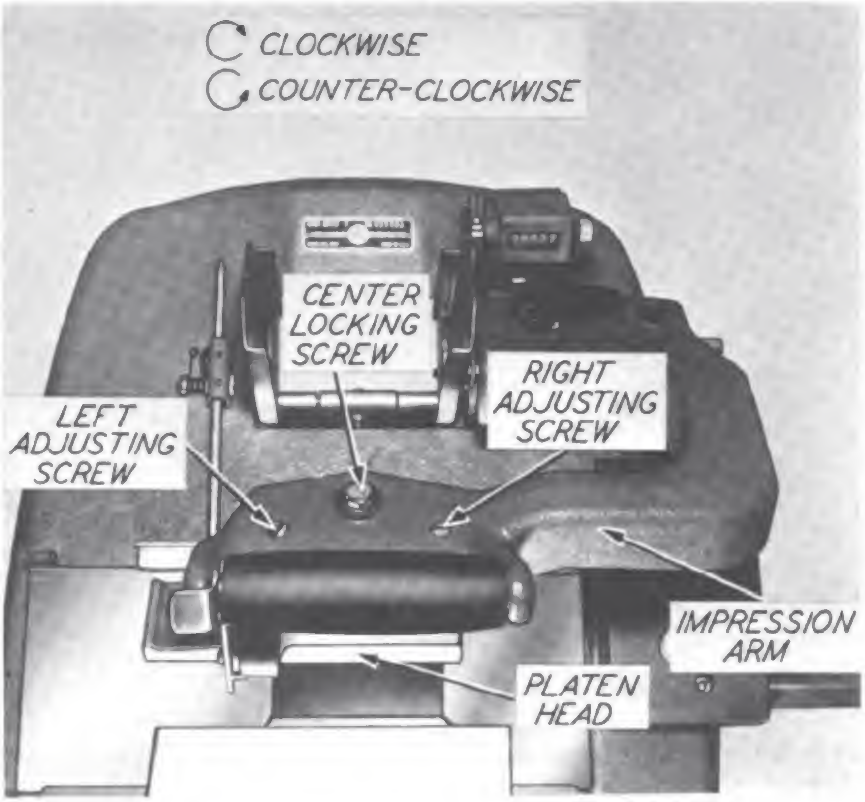

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Figure 5-28.—Adjusting the platen.

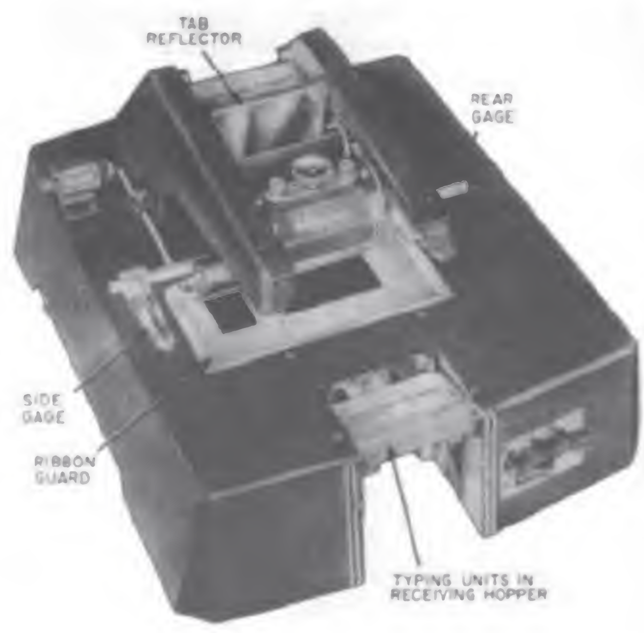

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Figure 5-29.—Class 900 Addressograph.

13. Loosen the screw in the ribbon drive eccentric plate and remove the C-washer from the other end of the eccentric; then take out the eccentric.

14. Free the ribbon feed mechanism by removing the nuts from the ribbon drive arm and mounting screws and by loosening the eccentric screws.

Reassembly and Adjustments

The reassembly procedure for the Class 900 Addressograph follows. Adjustments which should be made at this time are also discussed. Oiling should be accomplished at this time, too, when you can best get to the oil points. NEVER reassemble parts without adequate cleaning. Replace parts which may affect satisfactory operation of the machine.

1. Replace the drive shaft for the right ribbon and secure the ratchet wheel and ribbon core drive with the two tapered pins.

2. Install the ribbon feed and the reverse mechanism, illustrated in figure 5-33. Replace

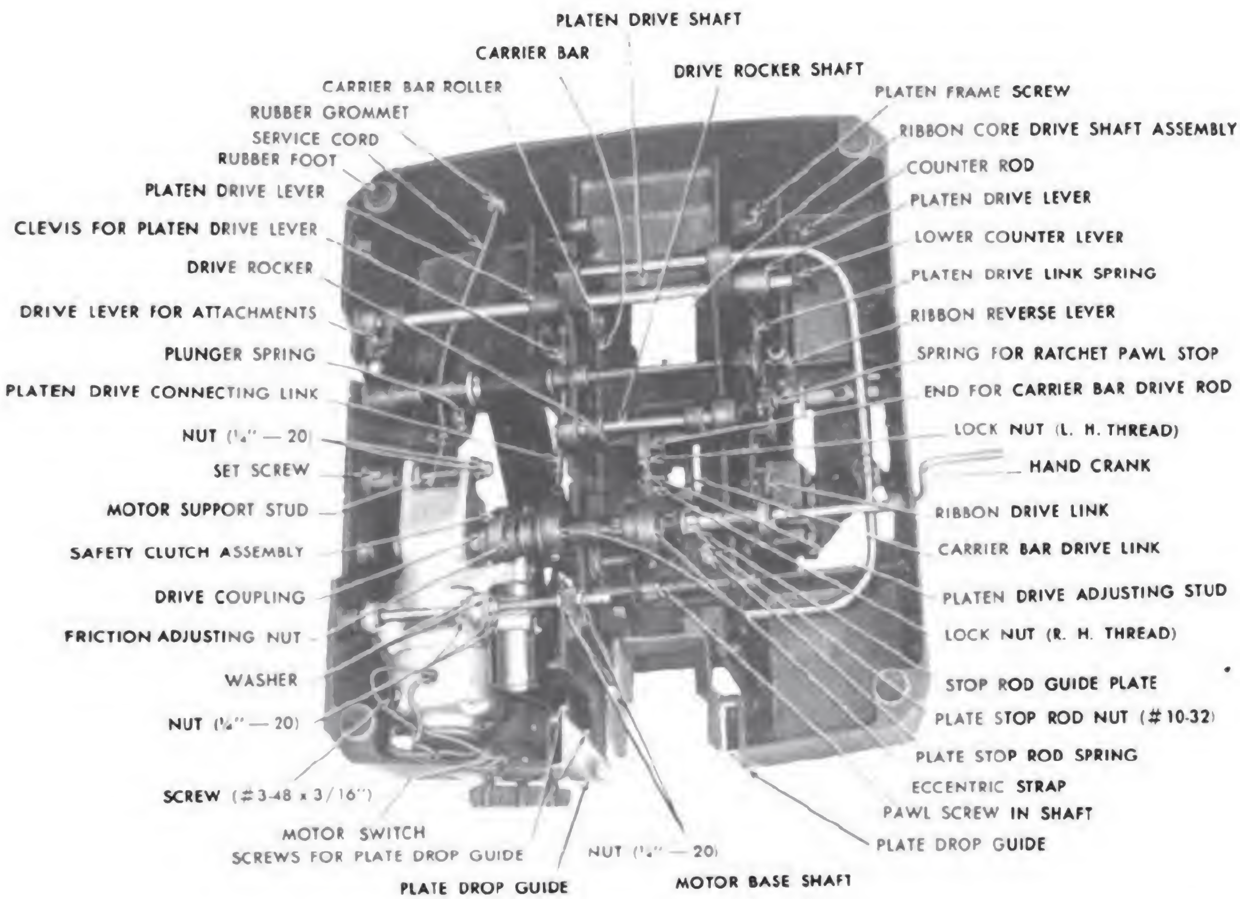

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Figure 5-30.—Class 900 Addressograph (bottom view).

the eccentric mounting screws and insert the eccentric drive assembly and plate. Put the C-washer on the eccentric drive and replace

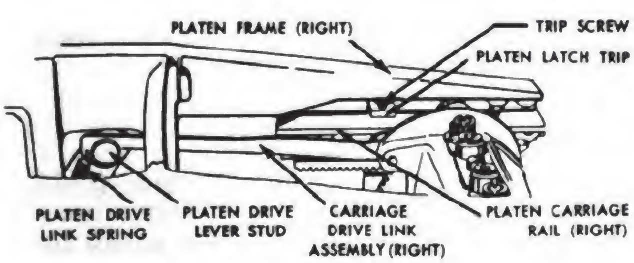

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Figure 5-31.—Platen drive link and drive arms.

and tighten the screw in the plate. Continue by turning the eccentric to its farthest point of eccentricity and engaging the upper ratchet wheel. Then turn the machine up and check the clearance between the ratchet wheel pawls and the wheels, on each side of the machine. CAUTION: Clearance on both sides MUST be equal.

3. Slide the carrier bars forward and inward and push their back extremities onto the rollers. Then replace the carrier bar drive link (face up) and the driver rocker assembly (face up). Insert the rocker shaft and its C-washer.

4. Replace the tracks, the one with the three friction pawls on the LEFT and the one with the

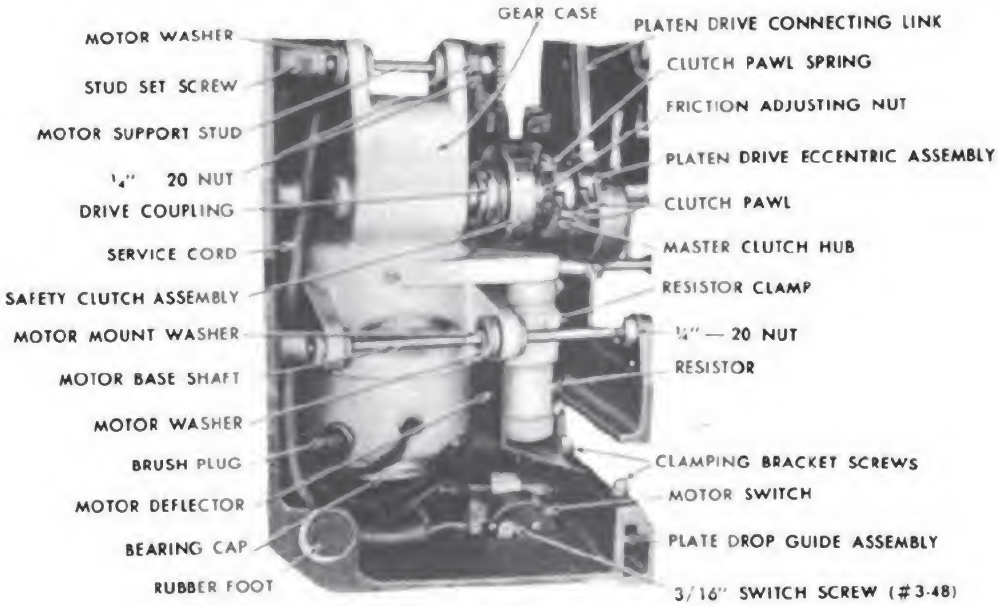

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Figure 5-32.—Motor and drive assembly.

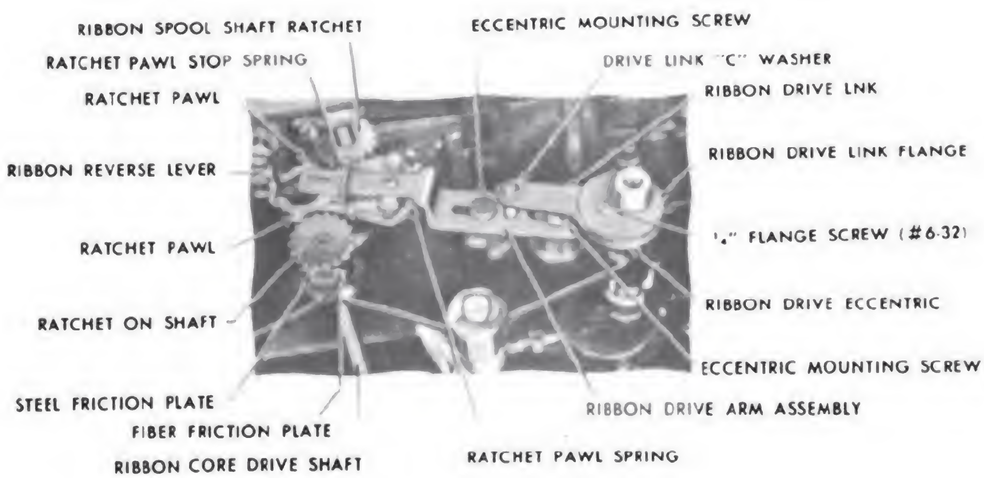

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Figure 5-33.—Ribbon adjusting mechanism.

two stop pawls on the RIGHT. Then check the clearance between the carrier bar pawls and the track pawls. NOTE: This clearance should be 1/64 inch. If it is too much, drive the rear part of the pawl down against the track; if the clearance is insufficient, drive the pin on the opposite side of the track.

5. Install the plate stop rod, guide plate, and the plate drive adjusting stud. Then release the lock nut a few turns on the stop screw for the carrier bar drive lever and insert the hand crank in the hole on the left side of the machine. See figure 5-34. Put a stack of plates in the magazine, depress the skip key, turn the crank

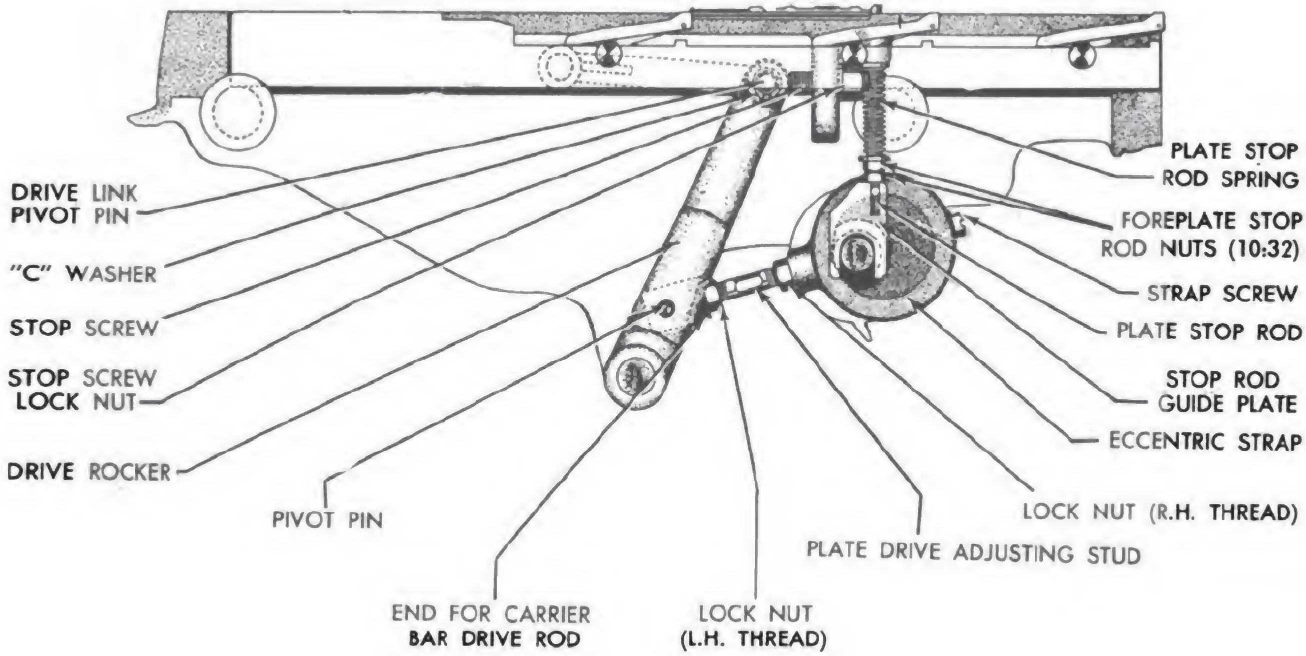

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Figure 5-34.—Carrier bars and drive link.

until you bring a plate into printing position, and check to determine whether the plate is at the plate stop (without binding). If the plate binds, increase the clearance between it and the stop by turning the adjusting stud. If the cam eccentric has no bind, lock the stud in place.

6. Bring another plate into printing position and measure the clearance between the plate and plate stop (carrier bars at the farthest point of their forward throw). Rotate the stop screw, as necessary, to make this clearance between .007 and .010 inch.

7. Measure the clearance between the address plate and the locking pawl (carrier bars at the end of their forward stroke). If this clearance is LESS THAN 1/64", file the end of the locking pawl; if the clearance is more than 1/64", replace the locking pawl.

8. Put the platen on its rails. Be sure that you engage the gear tooth with two RED lines with the FIRST tooth on the rack.

9. Maximum allowable rock of the platen is .002 inch. If the rock is greater than .002", adjust the top eccentric screws which hold the rollers (fig. 5-35). With the platen in its forward position, measure the clearance between the roller flange and the rails. It may be a BIT LESS than but NO MORE than .005 inch. Then restore the platen to its rear position and recheck the clearance. If the clearance between

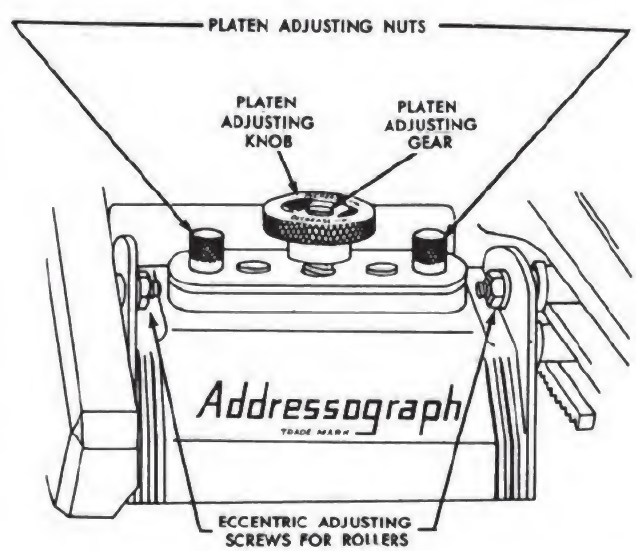

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Figure 5-35.—Platen adjusting mechanism.

the roller flange and the rails when the platen is in the rear position is greater than when the platen is in the front position, loosen the locking screws and gently tap the rear of the frame. Tighten the screws and repeat the clearance test.

10. Take an impression from an address plate in the printing position and check for equalized pressure of printing on the top and bottom lines. If the pressure is not uniform, adjust the platen side rails. To do this, loosen the rear pivot screw on each rail and turn the two adjusting screws (secured by lock screws) on the front of each rail to the extent necessary to equalize platen pressure at the top and at the bottom. Then tighten the lock and pivot screws.

11. Replace the two platen toggles and their C-washers.

12. Adjust the length of the platen stroke. If the stroke is TOO SHORT, the platen does not lock down properly and returns to neutral before it rolls all the way across the printing surface. If the stroke is TOO LONG, the carriage drive links do not lift off the studs on the drive arms.

To adjust the length of the platen stroke, turn the hand crank to move the platen all the way forward and check the platen toggles for full engagement (without play). Then turn the crank again and watch the platen for LIFT from the printing surface and the carriage drive links for LIFT from the studs on the drive arms. You can change the length of the platen stroke by loosening the lock nuts which hold the platen drive connecting link (between the platen drive eccentric and the platen drive lever). After you adjust the connecting link for proper length of platen stroke, retighten the lock nuts.

13. Check the trip of the platen to its neutral position. The trip should occur 1/8" before the platen reaches the end of its backward stroke. To change the point at which the platen trips, adjust the trip on the right rail of the platen frame arm.

14. When the platen contacts the trip on its backward stroke, it should spring to NEUTRAL with light, snappy action. This action is controlled by two torsion springs which raise the platen to its neutral position. If these springs have TOO MUCH tension, the platen is noisy and it may trip too soon; if the springs have TOO LITTLE tension, the platen does not engage the toggles on the forward stroke and may not latch on its backward stroke. With two wrenches, equalize the tension on both torsion springs.

15. A new Addressograph is usually equipped with a ribbon 1 5/8" wide, which is proper for printing six lines of type. Part of the rubber has also been trimmed from a portion of the platen roller on a new machine, so that it extends only 1/8" below the lowest line. If you must therefore change the machine to print SEVEN or NINE lines of type, make the following adjustments: (a) install a ribbon 1 7/8" wide; (b) put on a new platen roller and trim off enough rubber to have it extend only 1/8" below the bottom line of type, to ensure latching of the platen; and (c) install a new ribbon guard plate and supporting plate and readjust the length of the backward stroke of the platen roller.

16. Check the ribbon feed mechanism for clearance of the plate stop rod and STRAIGHT winding onto the spools. The ribbon feeds across the printing surface at an angle between 2 1/2 and 5 degrees; but you can make a small adjustment in this angle to get the ribbon to wind straight, by adjusting the ribbon guide.

17. When the SKIP key is depressed, the pin on the release pawl catches in the notch on the latch pawl, causing the latch pawl to engage the clutch which drives the carrier bars. After one complete revolution, the clutch disengages and locks (with the skip key up).

If the skip mechanism is properly adjusted, the clearance between the release pawl and the latch pawl notch MUST BE between 1/32" and 1/16 inch. Check this clearance by rotating the drive shaft counterclockwise with the hand crank. Then depress the skip key, and measure the clearance of the release pawl on the right side. Adjust for proper clearance by turning the adjusting nut connected to the skip key. Turn the nut IN to increase clearance.

18. Depress the REPEAT key, operate the hand crank, and recheck the clearance between the release pawl and the latch. If the clearance is not between 1/32" to 1/16", rotate the adjusting nut on the second rod from the right as required to get correct clearance. Then hold the repeat key down and work the skip key up and down. When the release key is properly set, there is no motion in the release pawl. Now hold the skip key down and work the repeat key up and down. Repeat the test. If the release pawl moves during either of these tests, further adjustment of the keys is required.

19. Plug in the service cord, turn on the motor, and check the operation of the CONSECUTIVE key. When you press this key, it should

operate the skip key and the repeat key simultaneously. If it does not do this, rotate the adjusting nut on the third rod from the right.

Lister Attachment

The lister attachment for the Class 900 Addressograph, shown in figure 5-36, differs from the lister on the Class 200 machine in two important respects:

1. The paper is wound on a cylinder mounted below the tracks, as illustrated.
2. Spacing on the lister is controlled by a perforated flexible rack (right part of illustration).

The manufacturer's technical manual for the Class 900 Addressograph gives instructions for mounting and operating this lister. Once installed, three adjustments must be made in order to ensure proper operation, as follows:

1. Loosen the stop screw in the lister drive lever and turn the hand crank until the lever reaches the end of its backward stroke. Then turn the eccentric pivot stud as necessary to bring the second hole from the back of the flexible hand FLUSH with the tapered end of the flexible band shield.
2. Without changing the position of the lister, remove play from the drive lever by turning the adjusting screw until it touches the stud in the drive lever bracket.
3. Tension on the friction drive clutch (extreme left of rewind cylinder) must be such that the paper winds smoothly and evenly onto the cylinder. If the paper buckles when the lister is operating, friction in the clutch is insufficient; if friction in the clutch is too great, the paper tends to stretch and increase the spacing. To increase friction in the drive clutch, turn the knurled adjusting nut clockwise; to decrease friction in the clutch, turn the nut counterclockwise.

CLASS 1900 ADDRESSOGRAPH

A Class 1900 Addressograph is illustrated in figure 5-37. Observe the size, and pay close attention to the nomenclature. Note the filing drawer, which (when in position in the machine) receives plates after they have been embossed in the same order in which they were fed into the machine. Observe also the foot trip pedals. The motor of this machine is either AC or DC, NOT BOTH, as designated by the Navy on the original order.

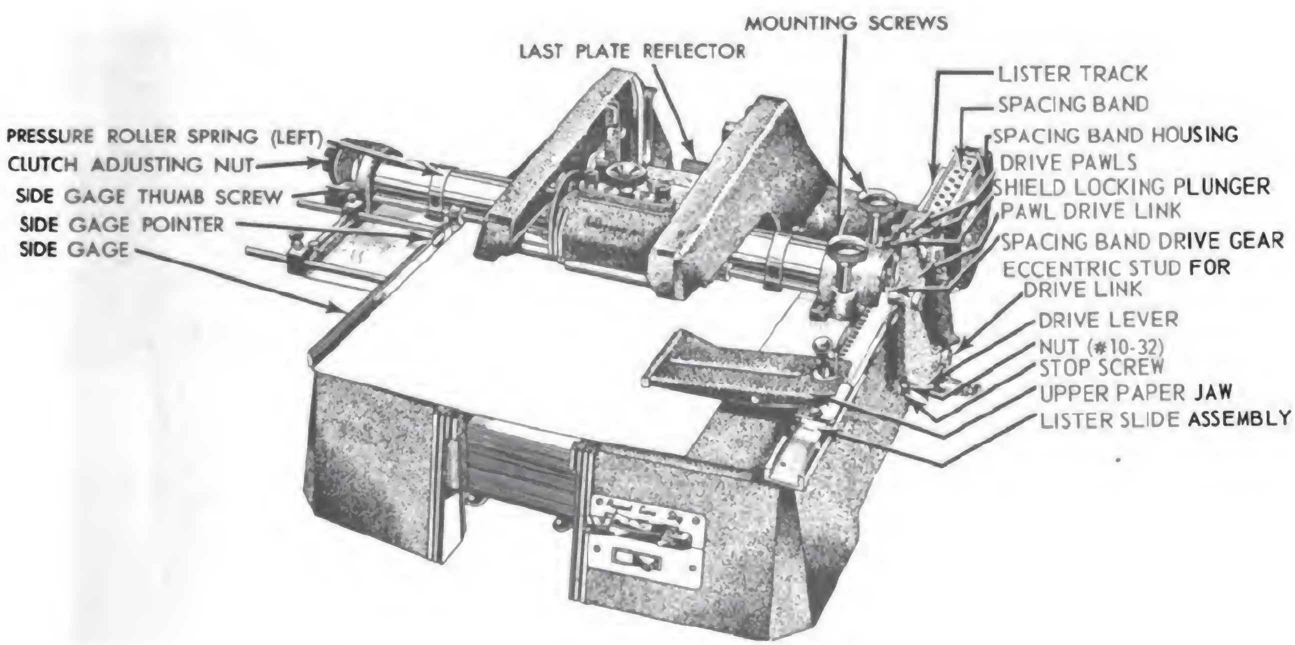

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Figure 5-36.—Lister attachment.

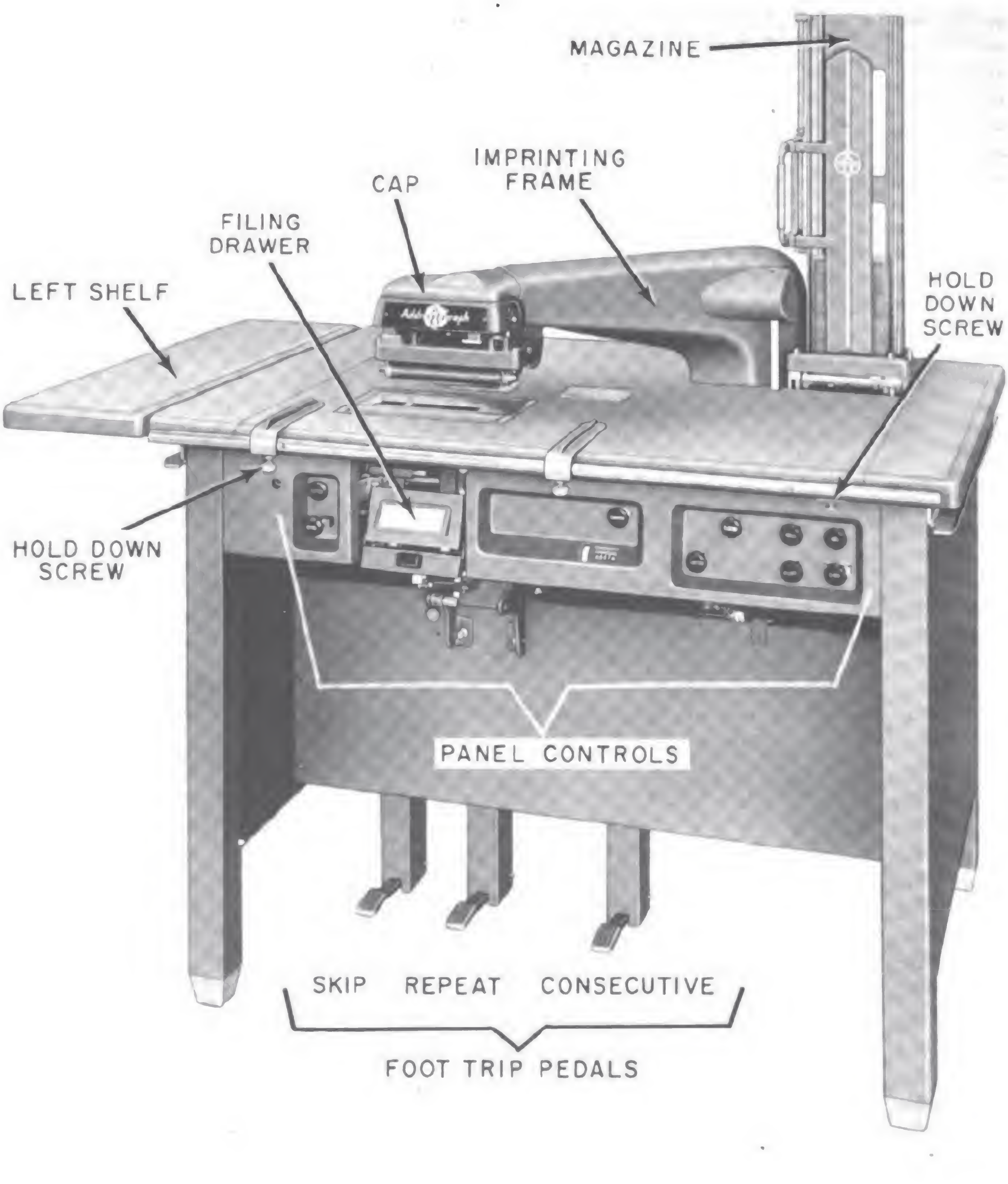

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Figure 5-37.—Class 1900 Addressograph.

The platen mechanism of the Class 1900 machine has a safety feature for protecting the operator's fingers. If the platen is accidentally operated while the operator has his fingers under it, the platen exerts SLIGHT pressure on the fingers and disengages the platen mechanism.

Foot pedals on the Class 1900 Addressograph control basic operations. If the operator desires to obtain ONLY one impression from each plate, he fully depresses and immediately releases the CONSECUTIVE trip pedal. If he wishes to obtain more than one impression from each plate, he fully depresses and immediately releases the REPEAT trip pedal. He can use the SKIP trip pedal, of course, to pass plates through the machine without imprinting.

Multiprinter

The multiprinter on the Class 1900 Addressograph enables the operator to make two or more impressions from a plate before the next plate in the magazine advances to the imprinting position. The type of multiprinter disk determines the number of impressions which can be obtained from each plate.

The plate feed control knob (CONSECUTIVE) on the lower part of the control panel puts the multiprinter in operation. This control has three settings: CONSECUTIVE, MULTIPRINT, and REPEAT. When you push the control all the way in, you throw the multiprinter out of operation. When you pull the control to the first notch (fig. 5-38), you put the multiprinter

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Figure 5-38.—Multiprinter controls.

mechanism in operation. If you pull the control all the way OUT, you put the multiprinter in the HAND REPEAT position, to make any number of impressions.

The procedure for changing a multiprinter disk is shown in figure 5-39. Observe the retaining screw which holds the disk in position. With the thumb of the left hand, depress the back extremity of the multiprinter arm; then remove the retaining screw by turning it in the direction indicated by the arrow. Slip the multiprinter disk off its shaft and replace it with the disk which will give the desired number of impressions. Then replace and tighten the retaining screw, and turn the disk as necessary to locate the roller on the multiprinter arm in any one of the low points of the disk.

Counter

The counter on the Class 1900 Addressograph is a self-contained, mechanical unit which visually records the number of impressions when the machine is operated on CONSECUTIVE, MULTIPRINT, or REPEAT. It does not accumulate when plates are skipped. When the counter control is pulled out on the five-figure counter (part A, fig. 5-40), the counter is put in operation. The reset wheel on the counter enables the operator to turn the wheels back to an ALL-ZERO position.

A six-figure counter for the Class 1900 machine is shown in part B of figure 5-40, with the nomenclature listed. You can operate this counter by turning knob A until guide B enters the slot. To turn the counter back to zero, turn the reset wing nut (F) clockwise.

Daters

Daters for the Class 1900 Addressograph are: REGULAR, DOUBLE, OVERHEAD, H, I, RR, and GG. The regular dater prints the date or auxiliary data to the right of the impression from the address plate. The double dater consists of a special platen carriage and platen roller for imprinting the date or other data on BOTH the right and the left of the address plate impression. The overhead dater prints data above or within the impression from the plate. H or I daters are known as PAYROLL plates, and they imprint the name, hours, pay, and so on. The RR dater is also known as a PAYROLL plate. Style GG plates with which the GG dater is used are also called payroll plates, but they differ from the RR payroll plates in that provision is made for as many as five lines of embossed payroll data, including gross and net pay deductions from two different pay periods, with the written amount of net pay in each case.

INSERTION OF REGULAR DATER PLATE.—Remove the support plate and the lower ribbon

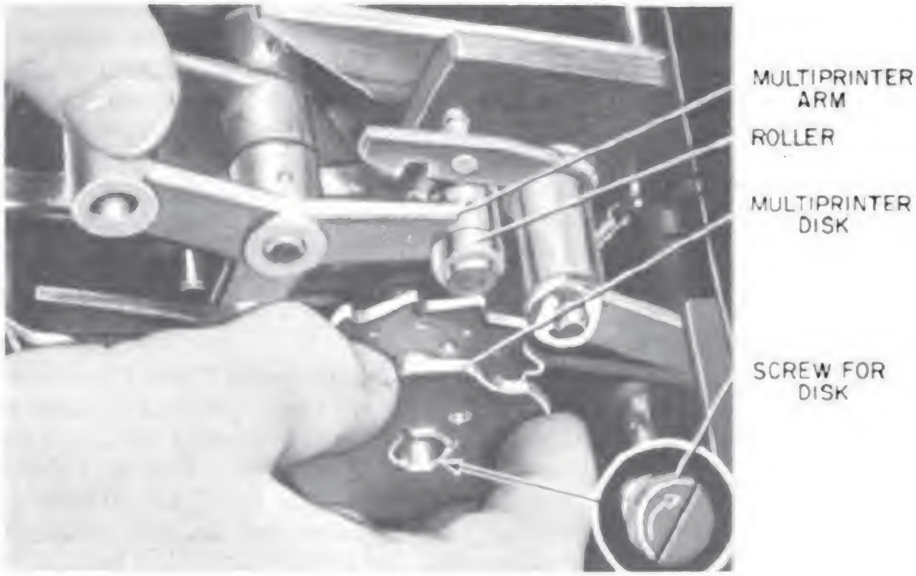

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Figure 5-39.—Changing a multiprinter disk.

guard section and push the dater control, (fig. 5-41) all the way in. Then grasp the forward edge of the clamp for the dater block and slip the entire dater assembly forward. Insert the plate under the edge of the retaining strip at the rear of the dater block and release the clamp to hold the date plate in position. Push the dater block (with date plate) into position under the ribbon and replace the lower section of ribbon guard and retaining plate.

INSERTION OF H OR I DATE PLATE.—If necessary, replace the regular ribbon support (part C, fig. 5-42) with the proper date plate holder for the H or I plate to be used in the machine. The H and I daters are shown in figure 5-42.

When it is not necessary to change the ribbon support on the machine in order to install an H or I dater, remove the ribbon guard and place the date plate under the clips. See part A of figure 5-42. Then insert the crank and remove slack in the ribbon.

INSERTION OF RR AND GG DATER PLATES.—Follow the same instructions given for the insertion of H or I date plates. See figure 5-43.

Automatic Ejector

The automatic ejector for the Class 1900 Addressograph is illustrated in figure 5-44. Observe the ejector mounting bracket and the receiving hopper.

You can install this automatic ejector by:

1. Removing the standard side gage and sliding the ejector mounting bracket onto the front gage.
2. Inserting the hose connection into the socket directly to the left of the magazine. See figure 5-45.
3. Installing the receiving hopper assembly onto the support rail at the left side of the machine.

After you complete the installation of the ejector, make these adjustments:

1. Place a form to be imprinted over the opening in the ribbon guard and set the rear gage as required to locate the impression in the desired position on the form.
2. Loosen the screws in the ejector mounting bracket (fig. 5-44) and slide the ejector bracket as necessary to have the ejector blade contact the right edge of the form. Then lock the screws.
3. Loosen screw A (fig. 5-44) and slide the ejector body until the ejector blade is located centrally along the edge of the form. Then lock screw A.

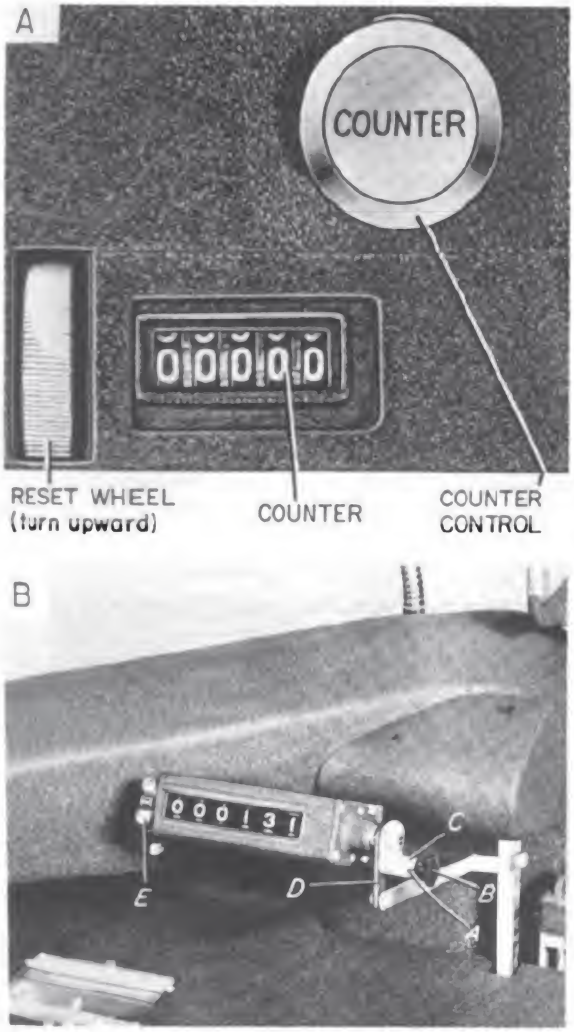

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Figure 5-40.—Class 1900 Addressograph counters.

4. Loosen the clamping screws in the receiving hopper and adjust the sides and the back piece to accommodate the size of the form.

Numbering Attachment

The numbering attachment is located to the left of the imprinting position, and it accumulates ONLY when BOTH the platen carriage and the plate feed mechanism are in operation for consecutive printing.

The numbering head can be set to number one by removing the lower section of the ribbon guard and support plate and pulling forward on the handle for the numbering device assembly (fig. 5-46). Turn the numbering wheels with a

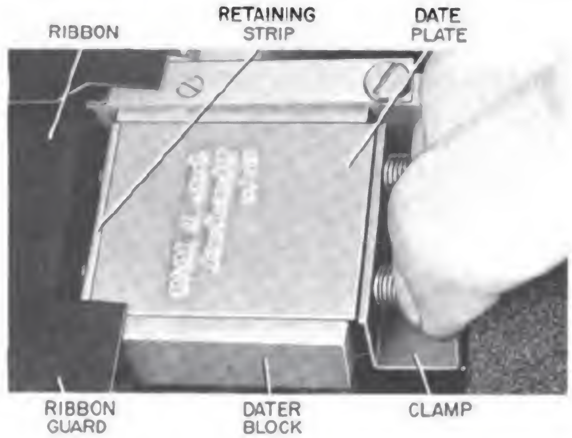

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Figure 5-41.—Inserting a regular dater plate.

stylus or pointed wooden stick, as shown in figure 5-47. NEVER use a screwdriver or a hard or sharp pointed tool to reset the numbering wheels, because they damage the printing faces of the digits on the numbering wheels.

To ensure freedom of movement of the numbering wheels, keep the numbering head clean. Bathe it occasionally in kerosene, and turn the numbering wheels to remove dirt and lint accumulations between them. Then wipe off excess kerosene to keep it off the ribbon and oil the head with a very light, clear oil.

Lister

The lister for the Class 1900 Addressograph is shown in figure 5-48, properly located in position on the machine.

To attach the lister, hold it as illustrated in figure 5-49 and insert the head of the support stud in the keyhole opening in the rear panel of the machine. Then rest the lip of the support flange on the edge of the support rail and slide the entire lister body to the left. Tighten the knurled locking nut and the left and right mounting screws.

Install the lister carriage in the space band guide by inserting the flanges of the guide rollers in the grooves at the forward end of the space band guide and then by sliding the lister carriage to the rear until the hole in the lister carriage guide plate extends about one inch beyond the rear end of the space band guide (part A, fig. 5-50).

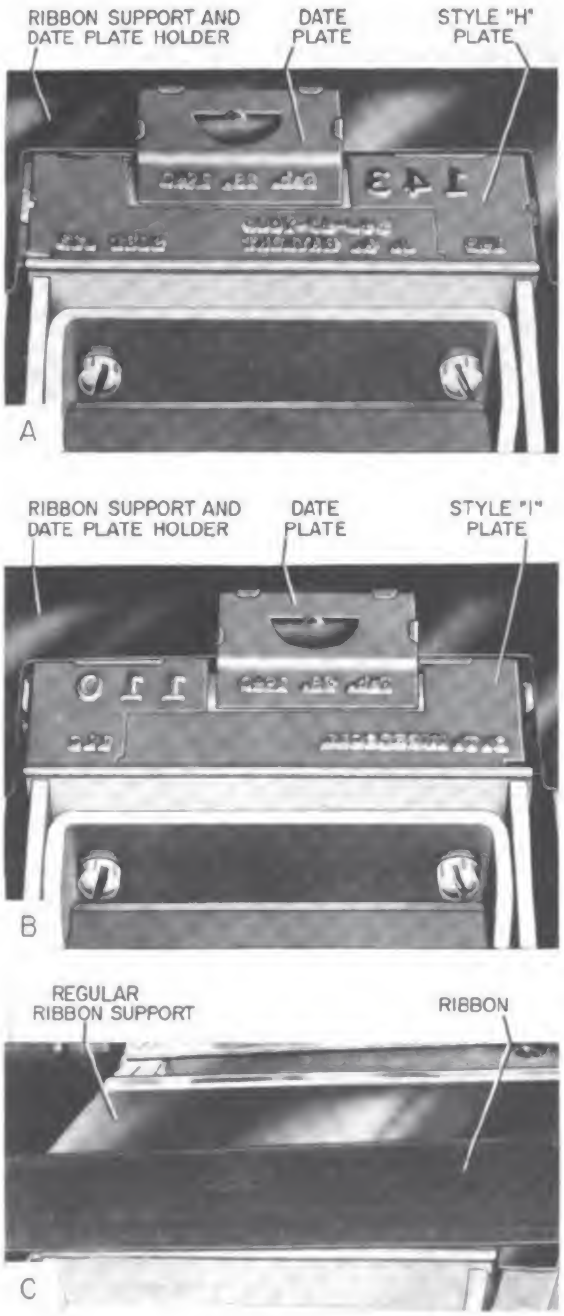

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Figure 5-42.—Inserting an H or an I date plate.

Hold the lister carriage with the right hand and grasp the forward end of the spacing band in the left hand and insert the connecting stud (part B, fig. 5-50) in the hole in the carriage guide plate. Then slide the lister carriage and the spacing band forward, about midway in the spacing band guide. Continue by sliding the spacing band guide into the top of the lister body until it contacts the slide guides. Tighten the clamp screws.

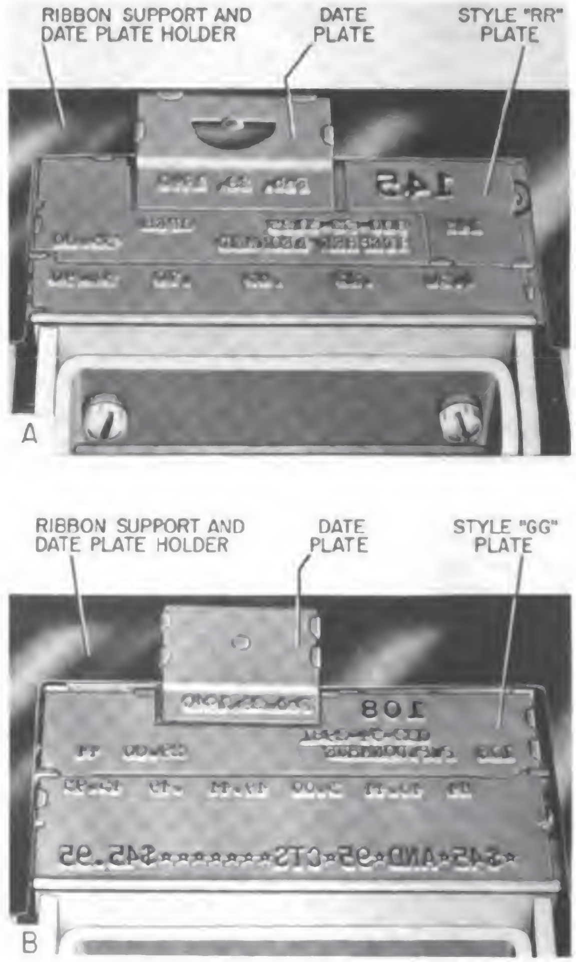

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Figure 5-43.—Style RR and GG date plates.

Study the manufacturer's technical manual to get additional information on the Class 1900 Addressograph.

CLASS 5000 ADDRESSOGRAPH

The Class 5000 Addressograph has combined in it the best features of all previously manufactured Addressographs, plus electronic controls. It is illustrated in figure 5-51. Note the various controls on the front of this machine, and also the foot pedals.

Many of the parts and mechanisms in the Class 5000 Addressograph are similar to those

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Figure 5-44.—Automatic ejector.

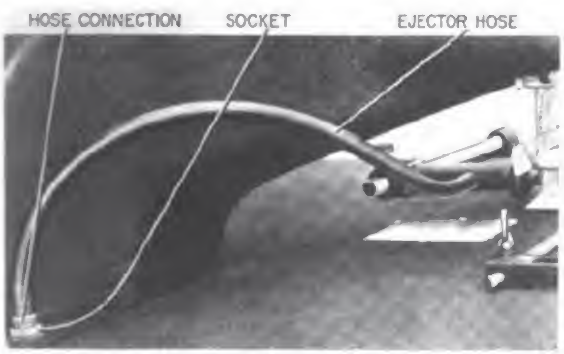

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Figure 5-45.—Hose connection for automatic ejector.

discussed in this chapter for other Addressographs. The electronic controls, of course, are a new addition; and the OVERLOAD SAFETY device on this machine operates when an excessive load is applied to either the carrier bars or the platen head. The overload safety knob is above the SKIP pedal. The only action required to reset this safety device is to: (1) turn off the motor, (2) push in on the overload safety knob, and (3) hold the knob in and turn it COUNTERCLOCKWISE until you hear a click.

Space in this chapter does not permit further discussion of the Class 5000 Addressograph. Consult the manufacturer's technical manual for additional details on operation, care, and maintenance.

GRAPHOTYPES

Some models of graphotypes have special attachments which enable them to emboss plastic or fiber identification tags and metal name plates; but most of them are designed primarily for embossing metal plates used in Addressographs.

All graphotypes have a special plate holder mounted on a movable carriage for holding

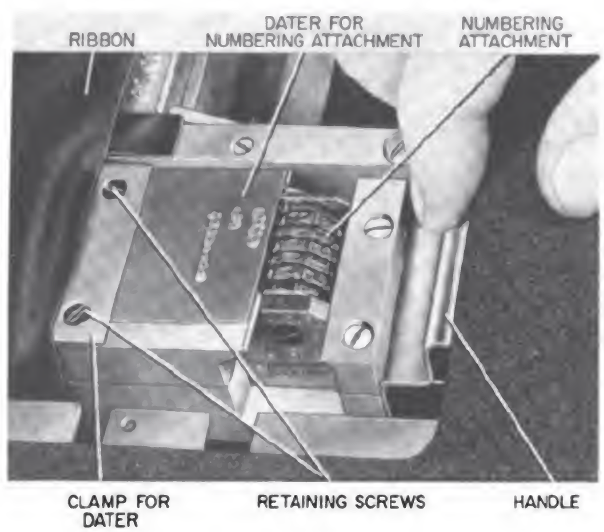

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Figure 5-46.—Changing dater for numbering attachment.

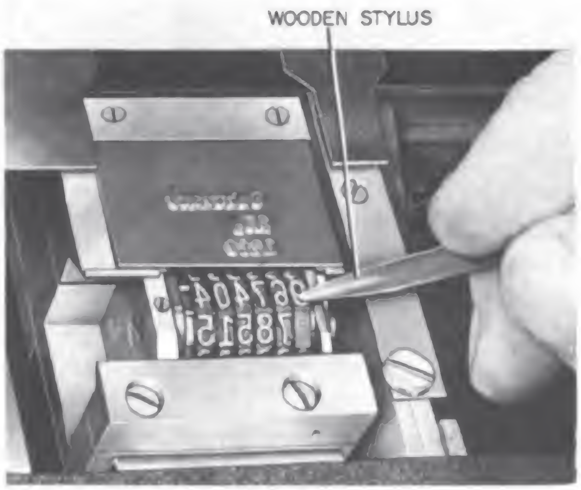

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Figure 5-47.—Resetting wheels of numbering attachment.

plates. When the operator embosses one character on a plate, the carriage moves automatically one space, in proper position for embossing the next character on the plate.

Characters are formed on the plates by dies and punches. Each strikes the plate simultaneously to form a letter, the die from above and the punch from below.

CLASS 6300 GRAPHOTYPE

The Model 6340 graphotype in Class 6300 embosses in the upper case only; Model 6380 embosses in both upper and lower case. Construction of the two machines otherwise is identical. A Model 6340 machine is illustrated in figure 5-52.

As you study the disassembly procedure for the Class 6300 graphotype, refer to the illustrations. Figure 5-53 shows a Model 6340 machine with the front cover plate, the carriage, and the carriage track removed. The procedure is as follows:

1. Remove the upper and lower guards and the drive gear guard.
2. Take off the spacing rod guide; then remove the carriage rail and assembly and the motor. Figure 5-54 shows the front view of the carriage assembly and figure 5-55 shows the rear view.

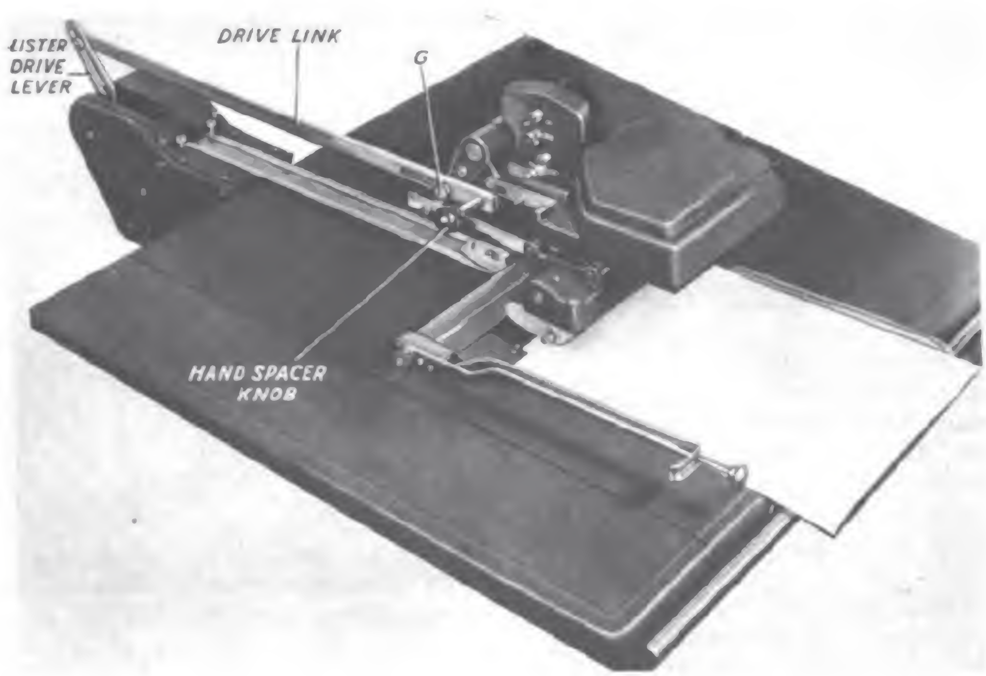

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Figure 5-48.—Lister for Class 1900 Addressograph.

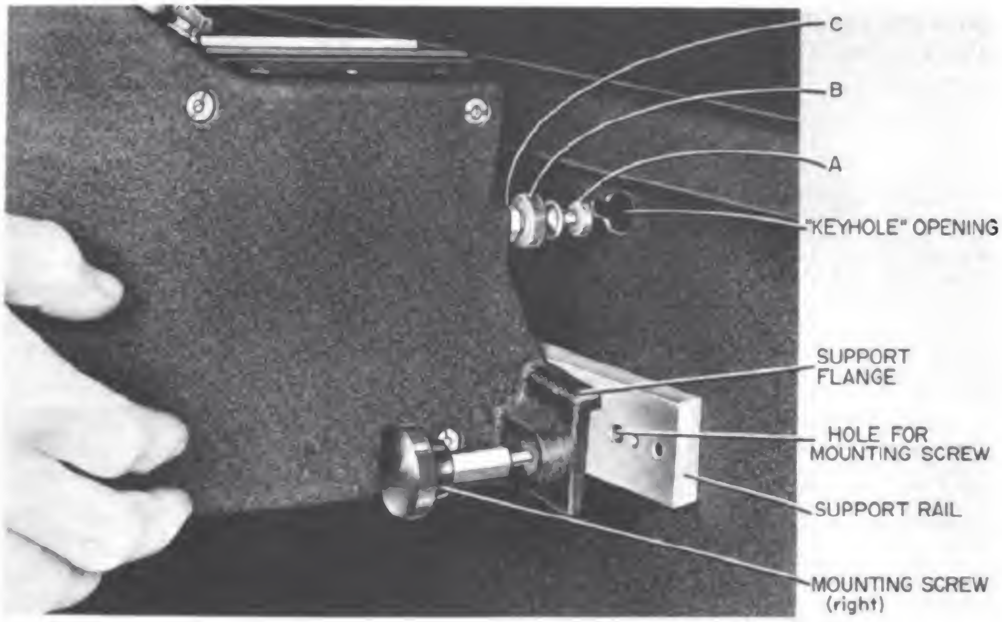

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Figure 5-49.—Procedure for installing lister.

3. Remove the die head and shaft by removing the nut from the pivot screw and lifting the trip lever out.

4. Drop the taper pins from the stop arm. CAUTION: Do NOT bend the shaft.

5. Loosen the clamp screws on the stop arm and the drive unit and drive the taper pins from the upper and lower retainer collars.

6. Remove nuts at the top of the shaft and take out the ball bearing thrust plug. Then remove the shaft by holding the trip latch back with one hand until the shaft passes it. Release the trip latch and remove parts from the shaft as you withdraw it. CAUTION: Do not lose the shims on the shaft (under the bearing) which control the position of the bevel gear on the drive unit.

7. To remove the key restoring mechanism, pull the cotter pins from the key restoring link and remove the screws which hold the assembly on the frame of the keyboard.

8. Remove the nuts from the screws which hold the keyboard assembly in place and lift the assembly off.

9. If necessary, remove the guide ring for the stop bars by loosening the nut on the clamp screw.

10. Remove the plate roller assembly and the die and punch operating mechanism, in order.

11. Remove the plate support.

12. To remove a die from the head without removing the head from the machine, drop the locking pin in the cover. Turn the die head clockwise and lift the locking pawl out of the retainer collar. Then position the slot in the spring plate over the die you wish to remove and lift the die out. Remove punches in the same manner.

Adjustments

When you reassemble a Class 6300 graphotype, make necessary adjustments, to the extent possible, as you proceed. Other adjustments will be required later, of course, whenever operational difficulties occur. Adjustments for the Model 6340 machine are as follows:

1. Adjust the stop arm trip latch before you replace the shaft in the machine. Put the trip rod in the shaft and raise the trip latch so that you can slide the rod under its end. Adjust the eccentric screw to the extent required to have the trip latch clear the contact plate of the stop arm by 1/32'' and then lock the screw.

2. Check the clearance between the die head and the plate support (in place on the machine). The clearance between the bottom of the plate support and the punches should be .007 inch.

Adjust for clearance by turning the lower nuts (on top of shaft) against the ball bearing thrust plug. Have the cap nut clear the shaft by .001 to .002 inch.

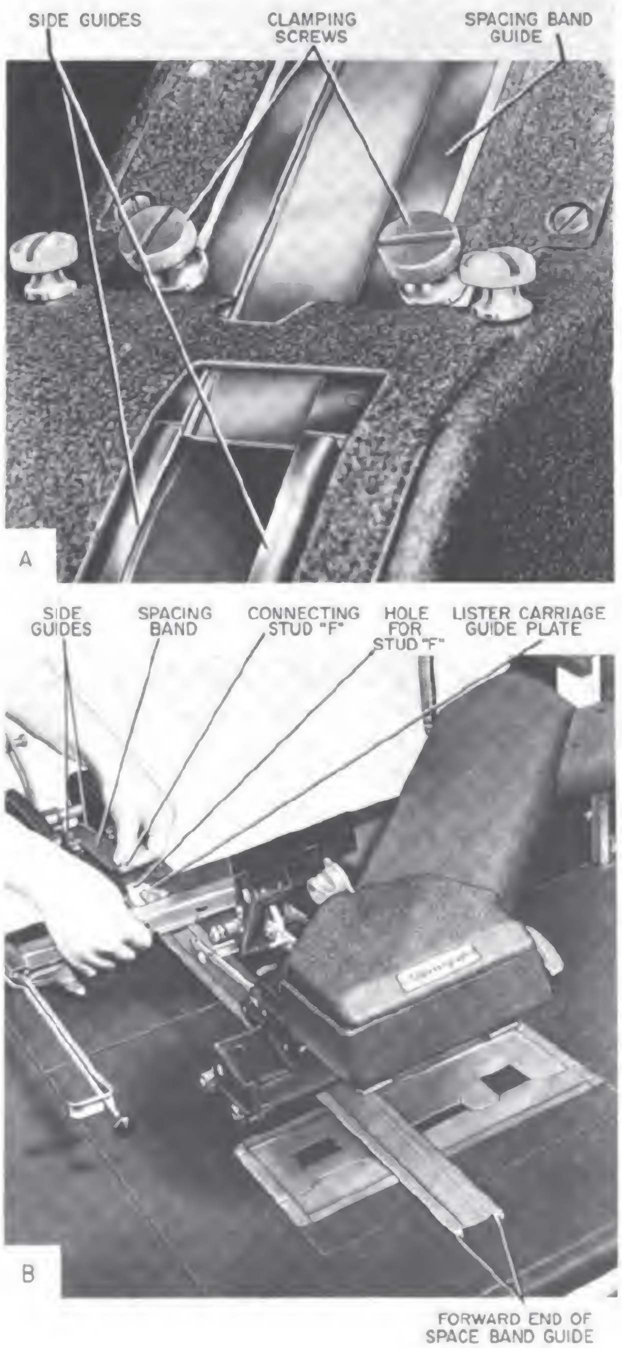

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Figure 5-50.—Guide for spacing band in position.

3. When the eccentric strap is at its lowest downward point, adjust the toggle links to make the two surfaces parallel, by removing the pivot pin at the top (rear) and making necessary turns.

4. Replace the trip return and the upper die arm and punch arm assemblies. Loosen the lock nut on the setscrew at the left end of the arm and turn the screw as necessary to have the lower die arm clear the anvil of the upper die arm by .007'', with the eccentric strap at its most upward throw. Then retighten the nut and adjust the felt pad until it just cushions the right end of the arm.

5. Replace the trip lever on its pivot screw and the trip rod in the shaft, between the guides on the end of the trip lever. Then replace the trip return lever and, with the shuttle block as far to the left as it goes and with the finger and arm engaging the shuttle block, adjust the eccentric and stud in the return trip lever as necessary to have 1/32'' leeway to the left.

6. Put the drive cam down to the limit of its throw and engage the trip return lever with the shuttle block. Then adjust the eccentric stud to give the shuttle block 1/32'' of play at the end of its stroke.

7. Put an address plate on the plate support, between the die and the punch. Trip the latch while the register is in line between the teeth and turn the flywheel by hand until embossing is completed. Stop the flywheel when the trip latch on the stop arm pops out from its retarded position and hold a scale beside the shuttle block to ascertain whether the shuttle block travels 3/32'' FARTHER before it returns. If it does not travel this distance, turn the eccentric in the trip lever to the left until it is properly set. Square the flat surface of the finger to align the center of its pin in the end of the arm.

8. The finger of the trip return lever should just clear the bottom of the shuttle block. To adjust the lever, loosen the nut on it and turn the screw; when adjustment is correct, lock the screw.

9. Adjust the register bolt to the extent necessary to have it clear the teeth of the die head by .005 inch. You can do this with the turnbuckle between the pivot lever and the register bolt.

10. Level the keyboard by means of the three studs. Then sufficiently tighten the nuts which hold the keyboard to hold it in place and put a block over the hole in the shaft to keep the trip

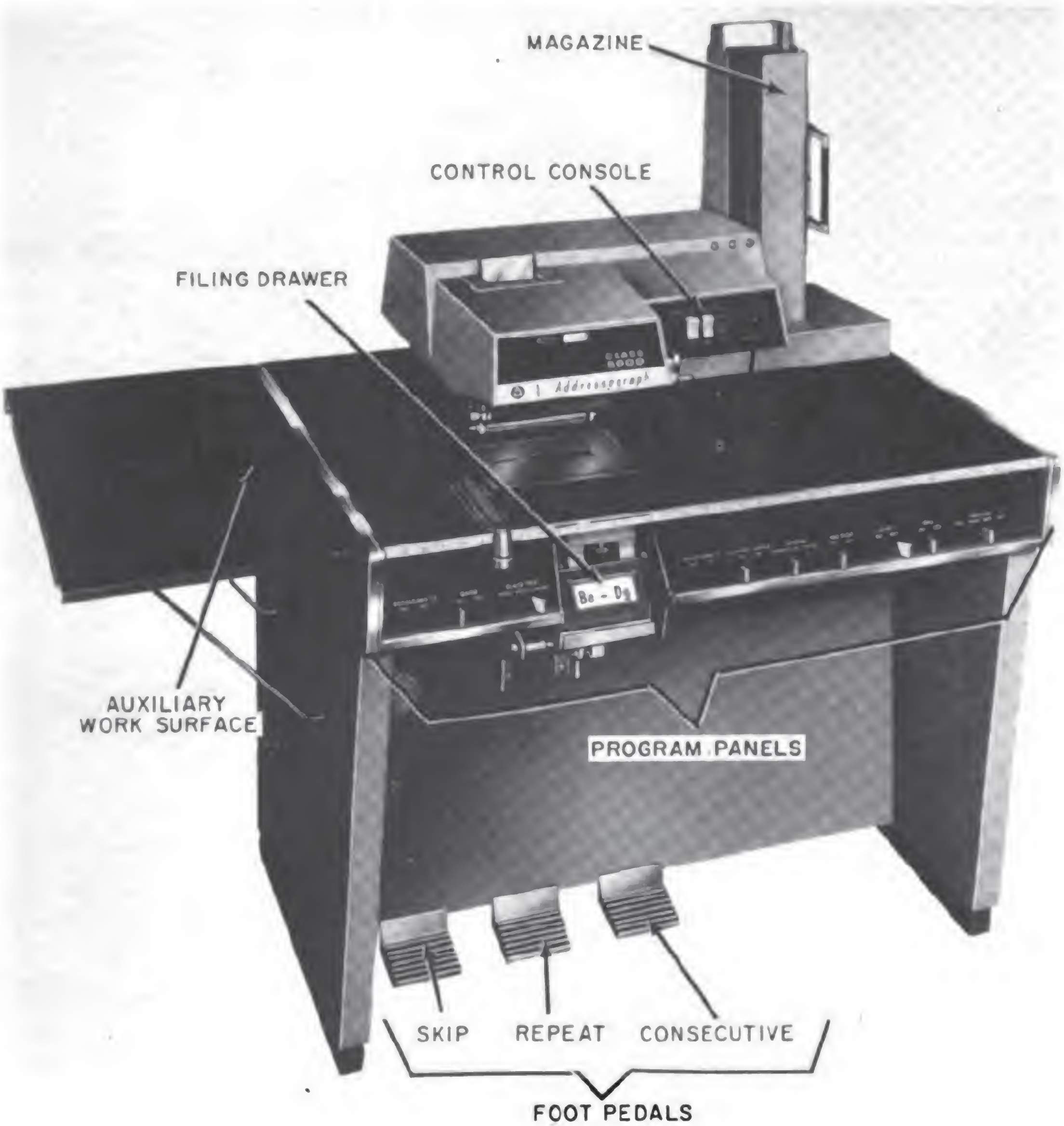

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Figure 5-51.—Class 5000 Addressograph.

latch out. Through use of characters 6, A, B, and P, center the guide ring for the stop bars with the guide ring of the stop arm swing.

Depress the key for character 6, lock the stop arm on it, and adjust the eccentric screw of the locking pawl as required to have it clear the stop block by .005'' when it is engaged. If the guide ring is properly set and the locking pawl has .005'' clearance when locked, the stop block should drop down when you pull back the blade for the keys. If the stop block fails to drop, push the stop arm to the right or to the left while you hold the blade back from the keys. If this action does not relieve the key, use a large screwdriver to shift the keyboard until the key drops. Repeat this test with the four characters (6,A,B,P) until all of them drop freely. Then line up the keyboard and the guide ring with the stop arm.

11. When the machine is in the neutral position, adjust the key restoring mechanism on the keyboard by forming the pin stop as necessary

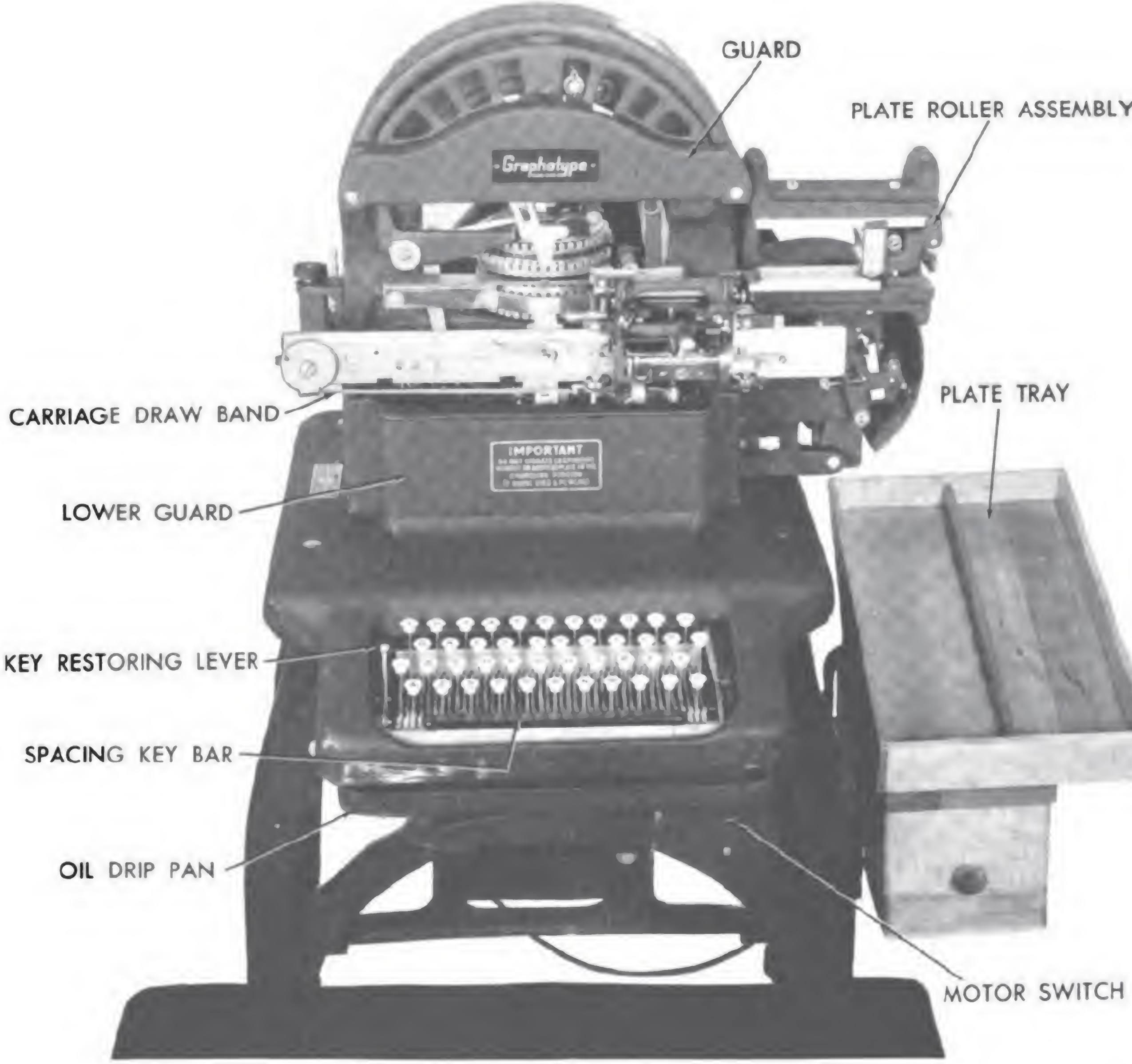

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Figure 5-52.—Model 6340 graphotype.

to have the drive rod clear the stud on the rocker by 1/32 inch. Then position the block on the connecting link so that its bottom edge is even with the head of the roller screw. This adjustment should give you 1/32" clearance above the bottom of the roller.

The two compression nuts which hold the rocker spring should clear the frame of the restoring mechanism by 1/16" when the rocker reaches its greatest eccentricity. In order to obtain this amount of clearance, adjust the two nuts on the drive rod. At the highest point of

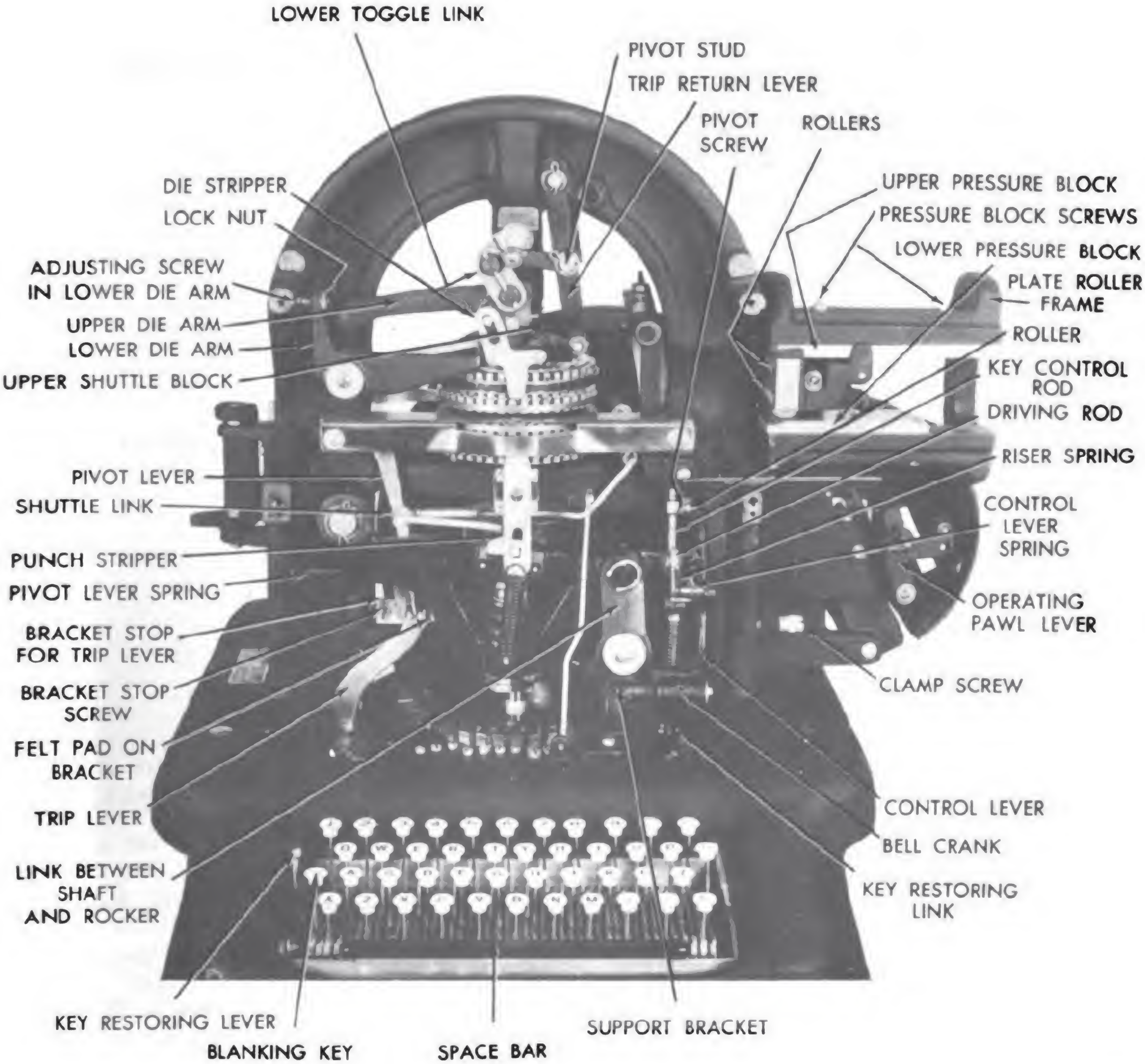

Figure 5-53.—Graphotype with carriage and tracks removed.

eccentricity, the rocker stud must clear the drive rod by 3/32 inch. If it does not have this amount of clearance, adjust the felt pad by cutting or shimmying.

The position of the rocker under the keyboard is controlled by a setscrew, which must be adjusted to clear the frame by 1/32 inch. Center the space bar on the keyboard and adjust the link between the space key rocker and the timing rocker as necessary to eliminate all play.

12. Check the automatic spacing adjustment. When the die rises up halfway, the carriage should move one half space; when the die reaches its highest point, the carriage should complete the space (just before the anvil of the die head leaves the die). You can control the

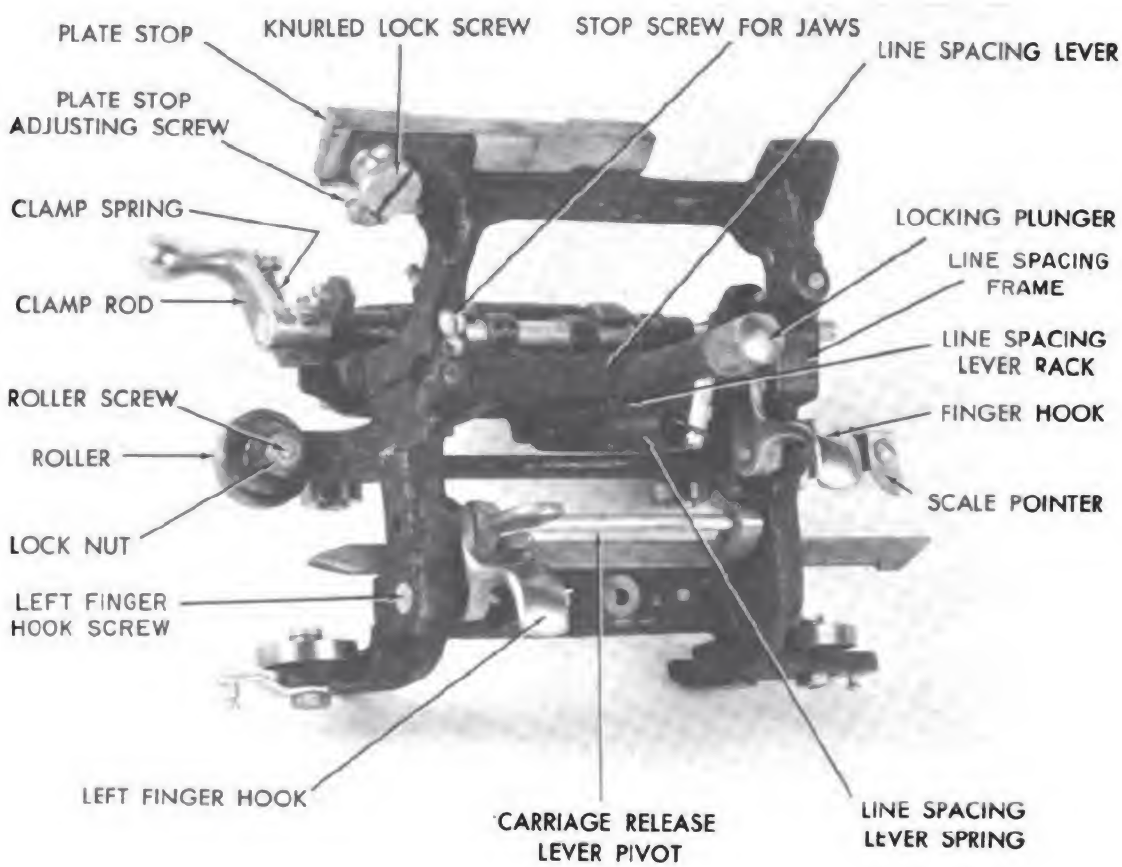

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Figure 5-54.—Model 6340 graphotype carriage (front view).

time of spacing by the carriage by adjusting the rod connected to the spacing rocker.

13. The eccentric at the end of the carriage release lever controls half spacing. Adjust first the eccentric at the left end of the release lever and then form the finger at the other end so that it clears the tooth in the release lever, above the top of the teeth in the escapement rack.

14. So adjust the screw on the bottom of the back spacer that it spaces the carriage one tooth at a time. The end of the arm should clear the escapement rack by 1/64" when it is not in use.

15. Keep the clutch clean and oiled with oil recommended or made by the manufacturer, and adjust as necessary to give it a 2 1/2 pound pull.

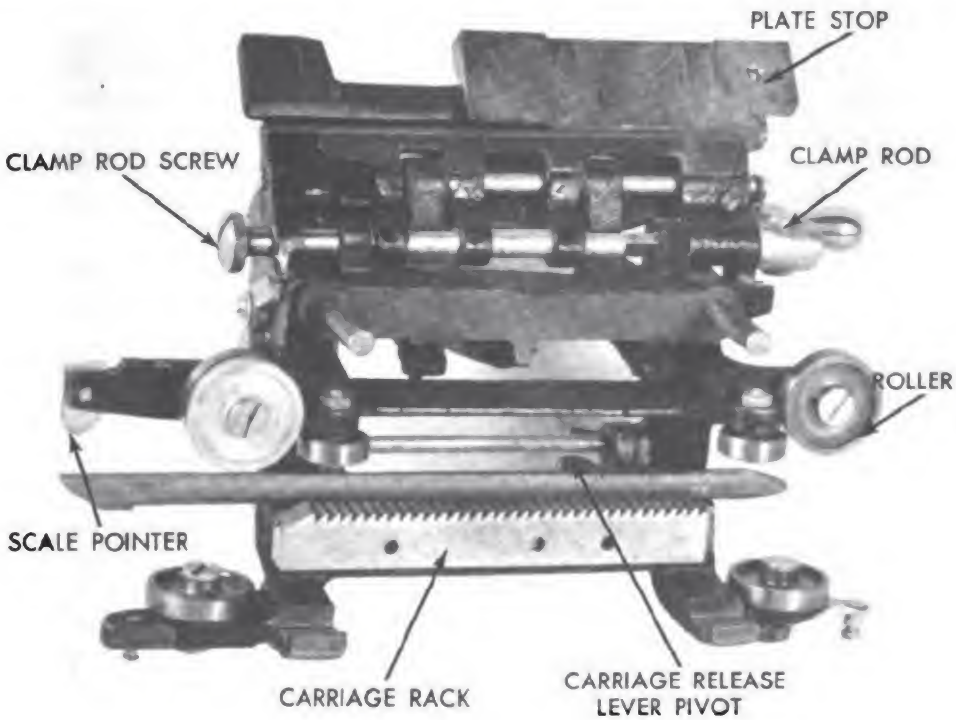
16. Form the key levers as required to adjust the height of the stop block in the guide ring. Regardless of their position, the keys should not bend.

Adjustments on the Model 6341 graphotype which differ with those just discussed follow:

1. The register pawl clearance is .010 inch.
2. The trip latch clearance is .010 inch.
3. The locking pawl clearance is .005 to .007 inch.
4. The shuttle block cannot engage unless the register pawl is engaged in the wheel of the die head. When the lock is up, the rocker of the register pawl must clear the pin by .015 inch.
5. Clearance for the trip lever is 1/32 inch.

Adjustments for the Model 6380 graphotype are as follows:

1. Adjust the stop arm trip latch when the shaft is out of the machine.
2. Replace the die head assembly and shaft and adjust the lower die arm while the machine is in the neutral position (anvil of the upper die



91.131X

Figure 5-55.—Model 6340 graphotype carriage (rear view).

arm down in the shuttle block). Adjust the die arm by loosening the lock nut on the screw at its left end. The clearance between the anvil of the upper die arm and the shuttle block on the lower die arm should be .007 inch.

3. With the die arm in the same position, equalize the distance between the anvil in the lower die arm and the anvil of the punch arm.

4. Replace the keyboard, key restoring mechanism, and the trip rod and trip lever and adjust the trip returning lever eccentric as necessary to have it restore the shuttle block when the block is at the extreme left of its throw. Adjust the eccentric in the trip return lever as required to get a clearance of 1/32 inch.

5. Adjust the trip restoring finger until it just clears the shuttle block while it is in the neutral position. CAUTION: Maximum allowable clearance under the shuttle block is .002 inch.

6. Depress the key for character 6 and bring the stop arm into contact with it. Then turn the flywheel by hand until embossing takes place, and then continue turning the flywheel until the trip latch snaps out. Stop the flywheel and put a scale alongside the upper shuttle block. Turn the flywheel slowly and check to determine whether the shuttle block travels 3/32" to the end of its stroke. If the travel is not 3/32", loosen the clamp screw which holds the eccentric on the trip lever and turn the bolt (and eccentric) with a wrench. Move the eccentric a small distance; then repeat the test.

7. With the machine in neutral, adjust the register pawl as required to have it clear the teeth on the die head by .005 inch.

8. Adjust the guide ring to the stop arm and center it. Then put a block under the trip latch and use the following characters to check the stop arm: 6, A, B, and P.

9. Latch character 6 up on its stop block and adjust the latch pawl as necessary to get a clearance of .005 inch. Make this adjustment by loosening the clamp screw and by turning the high point of the eccentric screw outward from the latch, with the latch pawl at 90° from the control plate surface.

10. Remove all play from the shift key by adjusting the turnbuckle. Do NOT move the sleeve collar.

11. Latch up character 6 and hold back the trip lever. Then turn the die head counterclockwise as far as it will go and hold it there. Release the trip lever and watch for a turning motion of the die head as the register pawl seats itself. Hold back the trip lever again and turn the die head clockwise. Then release the trip lever and recheck for motion of the die head. If there is no motion in either position, or if the amount of motion on either side of the register pawl is the same, the keyboard is properly set.

12. Depress the shift key for character 6. Then lock the stop arm and repeat the test described in the preceding step. Turn the turnbuckle to equalize the motion on both sides of the register pawl.

13. So adjust the collar under the shifting sleeve that the collar clears the sleeve by .010 inch.

14. Set the locking key to trip when you depress the shift key. Then so adjust the lever on the shift key that it clears all the keys when the shift key is engaged.

CLASS 6400 GRAPHOTYPE

A Class 6400 graphotype is shown in figure 5-56. Model 6440 embosses characters in the UPPER case only; Model 6480 embosses characters in both UPPER and LOWER case. The two machines are similar in construction and the following discussion applies to both.

Class 6400 graphotypes can be equipped with INVERTED carriages for embossing plastic cards. Spacing between lines of embossed characters is accomplished in a reverse direction from the standard procedure.

Attachments and Features

If a Class 6400 graphotype is equipped with more than one character spacing arrangement, the operator can easily change from one to the other by rotating a knob (fig. 5-57) to select the desired character spacing. Each character spacing is identified by its respective letter (C, fig. 5-57). Correct marginal stops may be selected by rotating the stop assembly (G, fig. 5-57). Each position has an identifying letter (H, fig. 5-57) for a pre-determined marginal stop.

To change the plate roller pressure, grasp the plate roll pressure knob (part A, fig. 5-58) and pull it out; then turn it as desired for embossing plates of different material.

To set pressure for such plate material as Addressoloy, take off the lower front cover (motor off), press the pressure control knob (part B, fig. 5-58) in, and turn it so that the letter A is directly above the indicating line (part B, fig. 5-58).

Maintenance

This section tells you how to replace dies and punches and oil the Class 6400 graphotype. Consult the manufacturer's technical manual for details on adjustments.

REPLACEMENT OF DIES (Model 6440).—When you replace dies or punches on a Model 6440 graphotype, check carefully during each step in the procedure to make certain that the notches in the dies and punches are all in alignment. The procedure follows:

1. Face the rear of the machine and turn the die head (fig. 5-59) by hand until the hole in the stripper disk is directly beneath the bottom end of the plunger.

2. Lower the plunger by turning the handle until it locates in the deep slot of the sleeve, allowing the lower end of the plunger to drop into a hole in the die head.

3. Turn the die head clockwise until the die to be replaced is located directly beneath the notch in the die head. Then remove the die by pushing it upward through the notch. NOTE: With the plunger in the hole in the die head, more effort is required when you first start to turn the die head; but after it is disengaged from its locking pawl, the die head turns with comparative ease.

4. Insert the new die through the notch in the die head with the die face down and the slot near the upper end of the die facing the center of the die head. Thrust the die downward until the top of the die is approximately even with the tops of the other dies in the die head.

5. Turn the die head clockwise until there is a distinct CLICK, indicating that the locking pawl is engaged.

6. Raise the handle and turn it to the shallow slot in its sleeve. CAUTION: Be sure the plunger is in the raised position before you turn on the motor.

REPLACEMENT OF PUNCHES (Model 6440).—Face the rear of the machine and raise

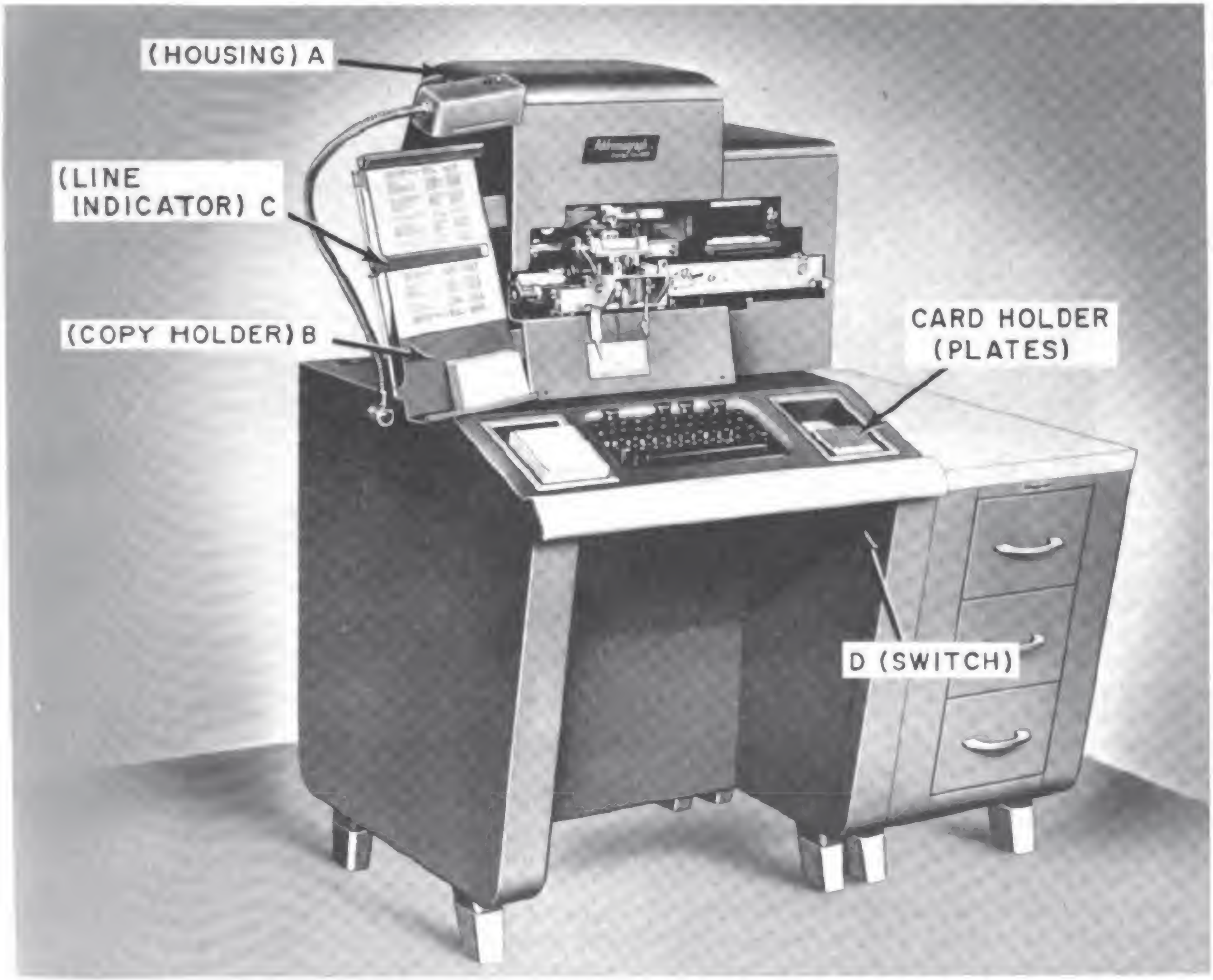


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Figure 5-56.—Class 6400 graphotype.

the lower plunger. Locate the handle of the plunger in the deep slot of the plunger sleeve and the plunger will then rise until it contacts the lower stripper disk, where it will be held by spring tension. Then do the following:

1. Turn the die head slowly in a clockwise direction until there is a distinct CLICK, signifying that the lower plunger has entered the hole in the lower stripper disk.

2. Turn the die head clockwise until the punch to be replaced is located directly above the notch in the lower stripper disk. Then remove the punch by pushing it downward through the notch in the disk.

3. Insert the new punch through the notch in the lower stripper disk with the face of the punch up in the slot near the lower end of the die head.

4. Turn the die head clockwise by hand until there is a click, indicating that the locking pawl has become engaged.

5. Press down on the handle of the lower plunger and turn the handle until it locates in

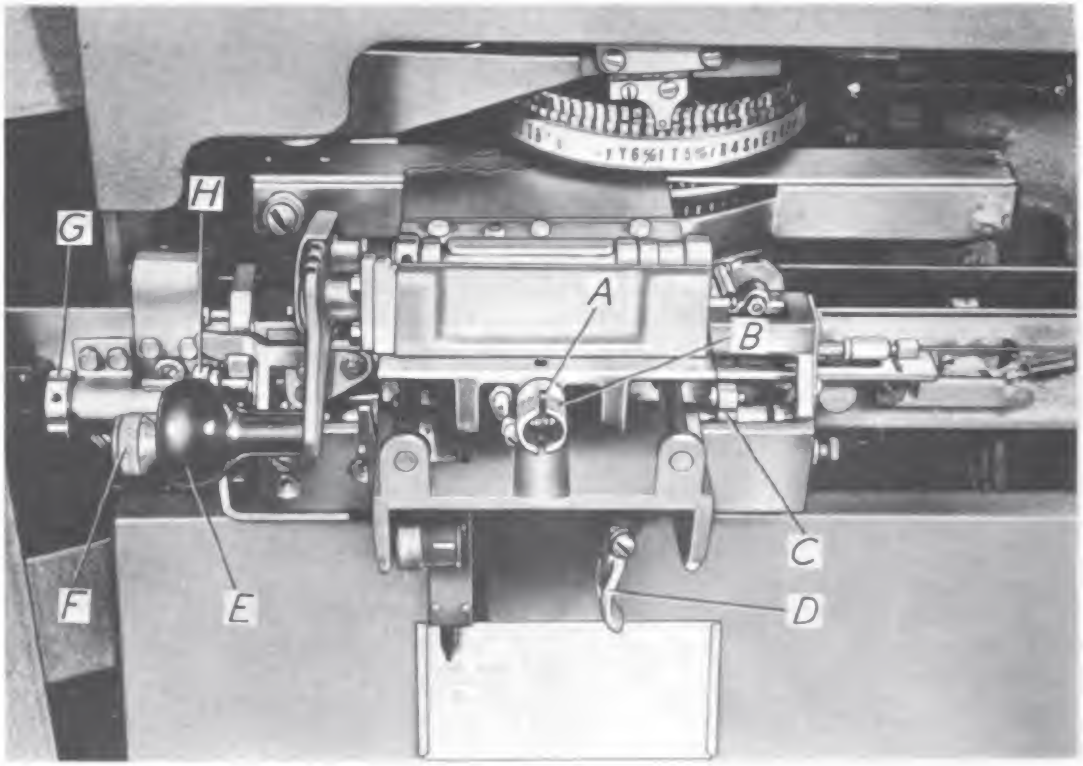

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Figure 5-57.—Quick-change character spacing and marginal stop mechanism.

the shallow slot in the lower sleeve, out of engagement with the hole in the lower stripper disk.

REPLACEMENT OF DIES (Model 6480).—To replace a die in a Model 6480 graphotype, proceed in the following manner:

1. Turn the die head by hand (fig. 5-60) until the die to be replaced is toward the rear, where it is accessible. Then insert a stylus (pointed wooden stick), as illustrated, in the slot at the top of the die and lift upward to release the die from the die head. (Face the rear of the machine when you perform this step.)

2. Insert the new die in the slot in the die head (die face down), with the large slot near the upper end of the die facing toward the outside edge of the die head.

REPLACEMENT OF PUNCHES (Model 6480).—The procedure for replacing a punch in a Model 6480 graphotype follows:

1. Face the rear of the machine and turn the die head by hand until the punch to be replaced is TOWARD the rear. Insert a stylus in the large slot near the lower end of the punch and press downward to release the punch.

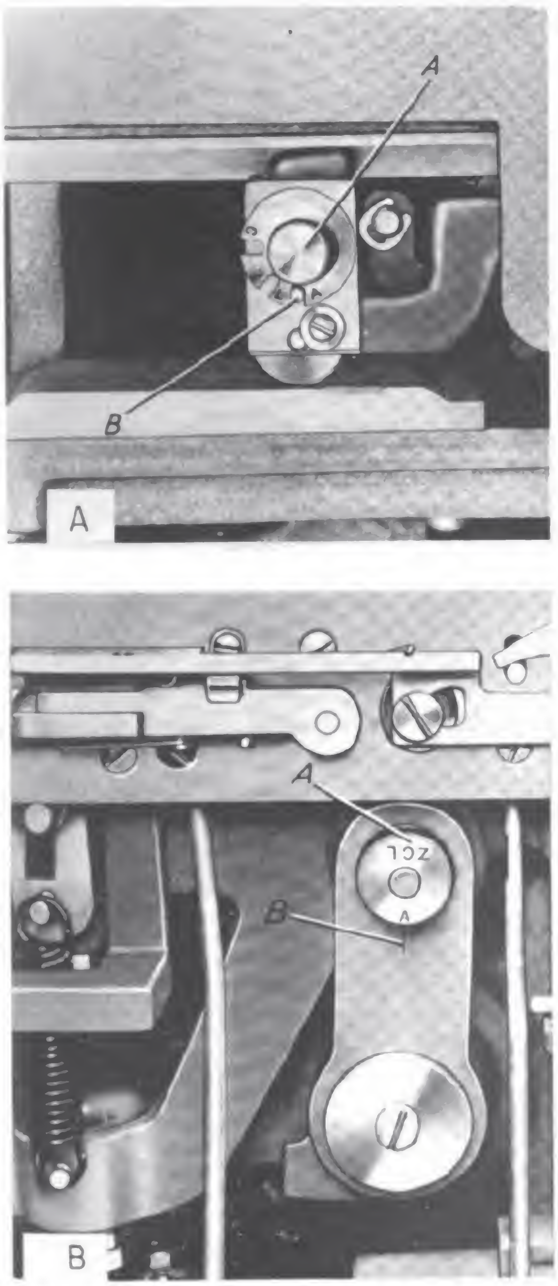
2. Then insert the new punch in the slot, face of punch up, and with the large slot near the lower end of the punch facing toward the outside edge of the die head.

LUBRICATION.—The lubrication points for the Class 6400 graphotype are shown in figure 5-61. If the machine is operated daily and continuously, lubricate the bearings once per week, or in accordance with specific instructions of the manufacturer.

The instructions given here for lubricating graphotypes apply to all classes and models, as follows:

1. Turn off the switch first.

2. Do NOT apply oil in the slots in which the dies and punches operate, nor to the dies and punches. If oil lodges in the face of a die or punch, the character will not emboss distinctly.



91.134X
Figure 5-58.—Quick-change pressure device.

3. After eight hours of use, apply a few drops of recommended oil to the lubrication points.

4. Apply 25 drops of oil to the clutch once each month.

5. Bearings of the motor are packed in grease at the factory. Additional greasing should therefore be accomplished in accordance with the manufacturer's instructions, or by factory-trained mechanics.

6. Do NOT over oil anything, because excess oil may run onto the faces of dies and punches, resulting in unsatisfactory embossing.

7. The common-sense rule of oiling is this: Oil all moving parts in accordance with the amount of usage the machine receives.

CLASS 300 GRAPHOTYPES

The Model 350 graphotype in Class 300 is shown in figure 5-62. This is a small, compact machine which is easily operated. Adjustments of parts are similar to those for other models of graphotypes; but keep the technical manual for the machine available for ready reference.

Inspect embossed characters on the plate periodically, and keep the type in good condition. Because punches and dies are subject to breakage, inspect them frequently and make necessary replacements. The procedure for removing type from the type rack of this graphotype is illustrated in part A of figure 5-62. Insert a screwdriver or a similar metal tool in the notch in the back of the type and pull it out. To install type, insert it in the proper slot with the notch toward the rear of the rack and push the type into the rack until it snaps into position.

You can remove the type rack from this graphotype by opening the front cover (part B, fig. 5-62), pressing down on the stop latch, and moving the type rack to the left.

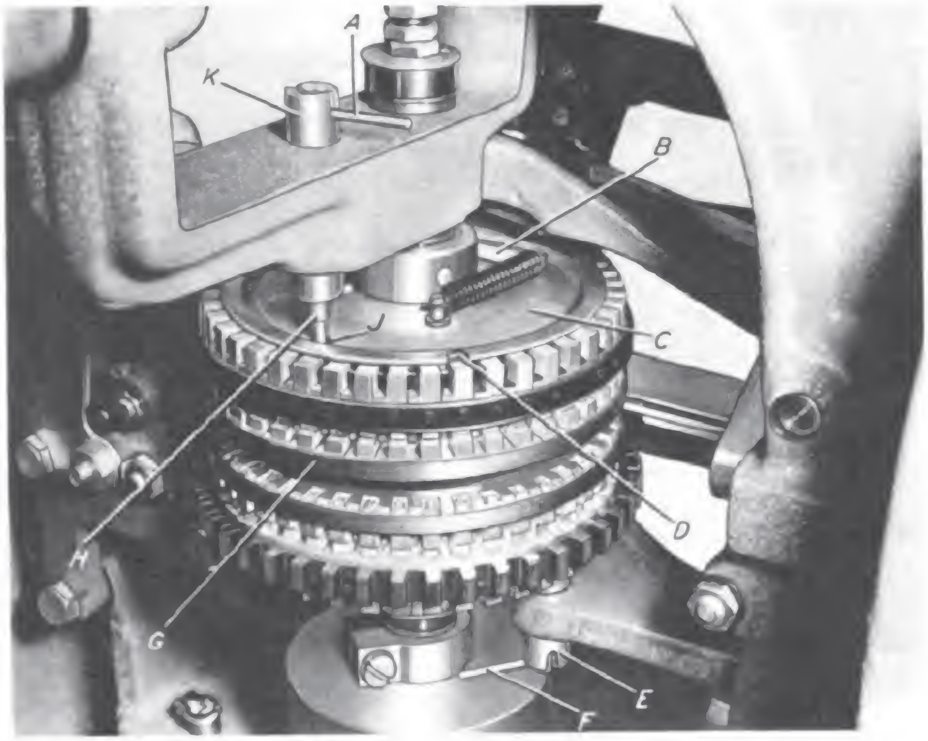


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Figure 5-59.—Procedure for replacing dies.

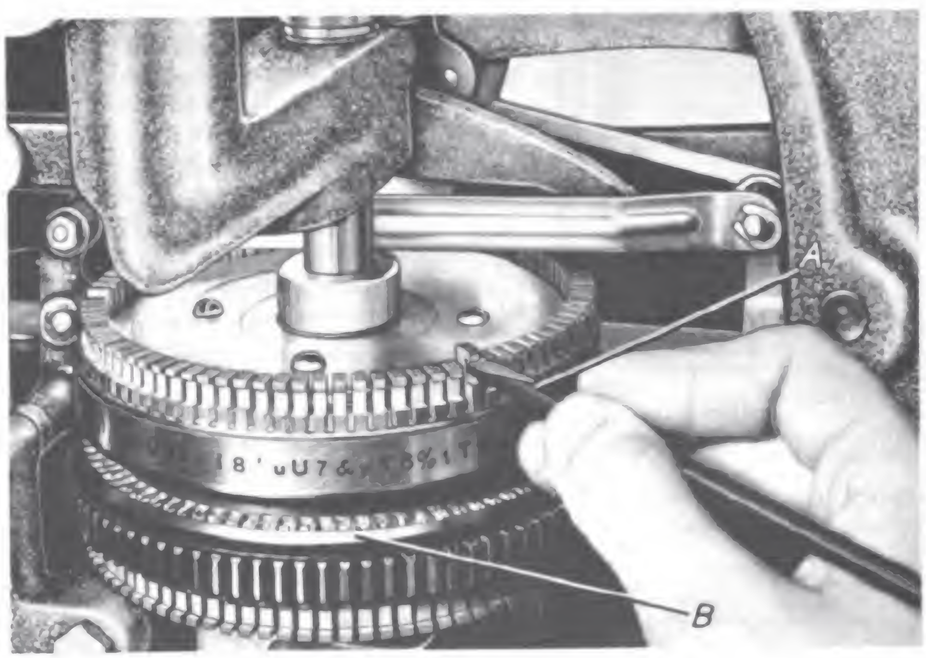

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Figure 5-60.—Replacement of dies and punches (Model 6480 graphotype).

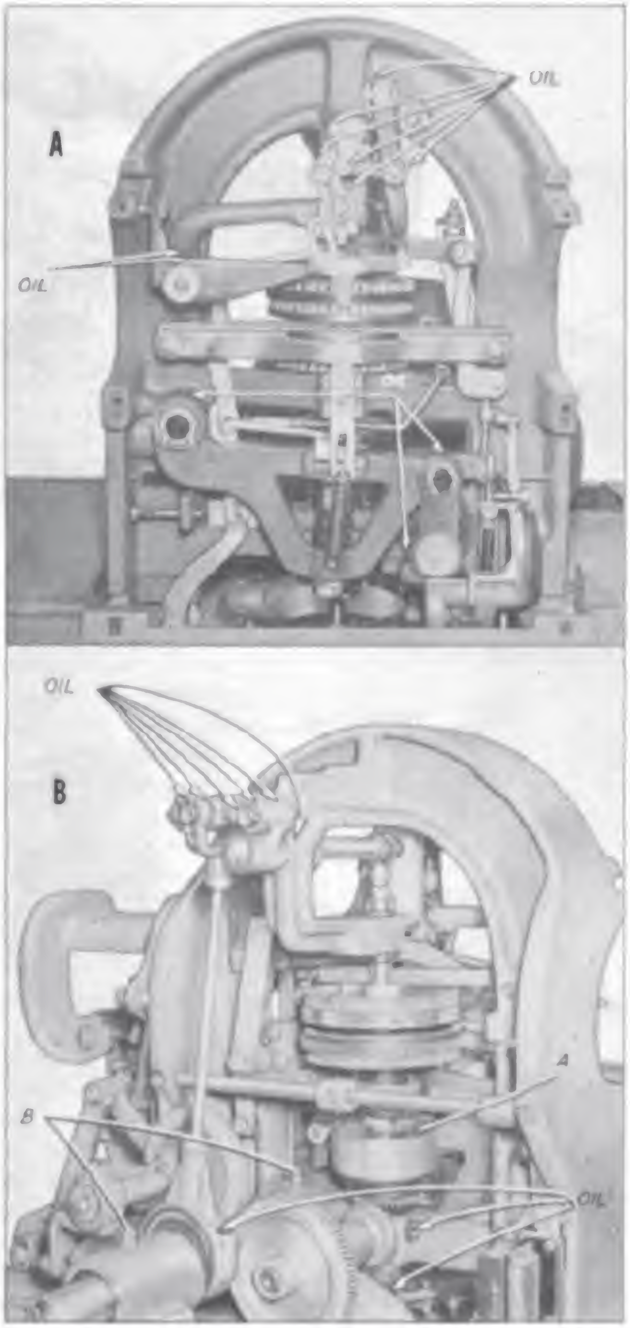

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Figure 5-61.—Lubrication points on a Model 6400 graphotype.

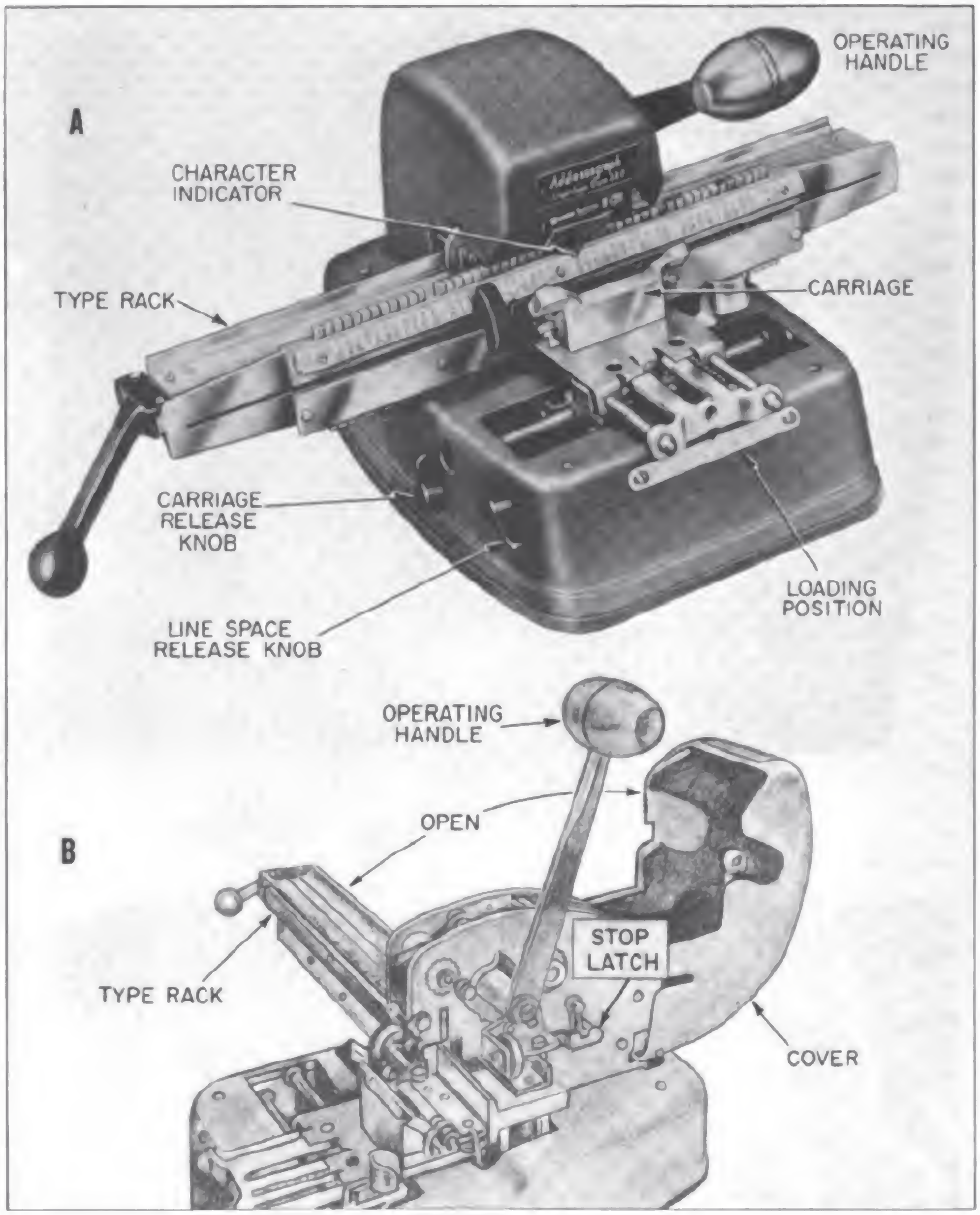

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Figure 5-62.—Model 350 graphotype.

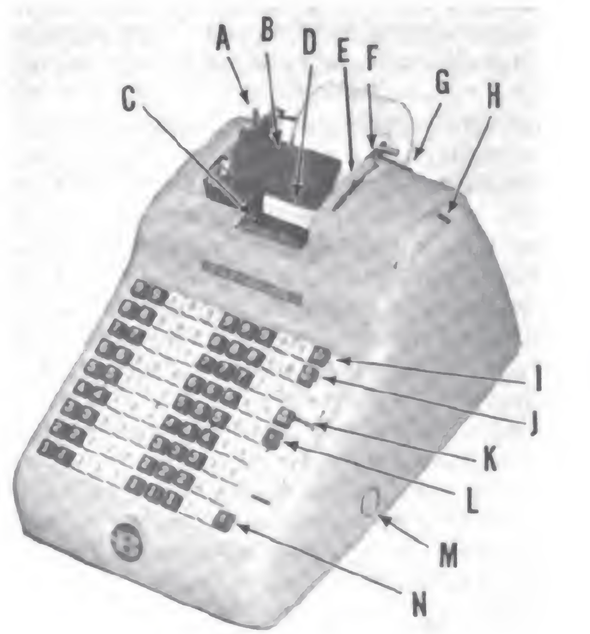
CHAPTER 6

ADDING MACHINES

Because of the type of work they must perform, adding machines are composed of many complicated mechanisms which must function in a precise manner for the machines to perform satisfactorily. Aboard ship, Instrumentmen have the responsibility for cleaning and adjusting adding machines, and they may also be required to repair and maintain them.

One of the qualifications for advancement in rating to an Instrumentman First Class is: "Disassemble, clean, reassemble, and make minor adjustments to calculators, adding machines, and cash registers." The material in this chapter is therefore designed to give you the knowledge you need on adding machines to qualify for advancement in rating, and also to increase your capabilities as an instrument mechanic when you are on active duty in the Navy. After you have had considerable experience working on adding machines in instrument shops, you will know how to perform most any type of maintenance on them.

The Navy procures adding machines from various manufacturers, but space in this chapter permits discussion of only one make. If you learn well the operation of the mechanisms of these machines, you will be able (with the aid of manufacturers' technical manuals for specific models) to perform acceptable maintenance and/or repairs on all makes and models of adding machines. Burroughs adding machines have been selected for consideration as a representative type for two reasons: (1) they are used extensively throughout the Navy, and (2) some series may be used as cash registers, on which you are required to perform maintenance.



A. Pressure roll release lever
B. Writing table
C. Platen
D. Transparent tear-off blade
E. Jump total spacing lever
F. Adjustable form spacing lever
G. Roll paper shaft
H. Platen twirler
I. Subtotal key
J. Total key
K. Non-add key
L. Repeat key
M. Swing-away shutter for handle insertion
N. Error key

91.139X

Figure 6-1.—Series P full keyboard adding machine.

BURROUGHS SERIES P ADDING MACHINES

Burroughs Series P adding machines, one of which is illustrated in figure 6-1, are manually and manually-electrically operated, and they are also used for cash registering and bookkeeping. The full keyboard has as many as thirteen columns of keys for listing figures or other information to be printed either on roll paper or bookkeeping forms.

These machines are available with single or duplex registers—some for accumulating ADD items only and some for accumulating ADD and SUBTRACT items. A wide range of keyboard and accumulator mechanisms, plus many other basic and optional features, permits flexibility of use of these machines.

SERIES P100 MACHINES

Series P100 adding machines are basic of the Series P line; other series have ADDITIONAL mechanisms designed to perform definite functions. Except for features applicable to certain series and/or styles, the number, construction and arrangement of registers in machines constitute the MAJOR differences in the various series.

Series P100 machines are operated manually or electrically and accumulate PLUS items only. Figures indexed on the keyboard print on a roll paper tape or form inserted in the carriage. Items may be repeated by depressing the REPEAT key, and they may be printed without accumulation by depressing the NON-ADD key. A total or subtotal can be obtained by depressing the TOTAL or SUBTOTAL key, respectively.

Uses of the Series P100 adding machine include: (1) accumulating figures on statements, deposit slips, and inventory slips; and (2) GENERAL PURPOSE cash registering, when equipped with a paper rewind device and mounted on a cash drawer.

SERIES P200 MACHINES

Series P200 adding machines are also operated either manually or electrically and they accumulate both PLUS and MINUS accounts. Repeat, non-add, and total action on this machine is identical with that of the Series P100 machine.

SERIES P300 MACHINES

Series P300 Burroughs adding machines are operated electrically ONLY; otherwise, basically, they are similar to the Series P100 machines. The addition of a second independently controlled adding register to this machine, however, gives it a wide variety of applications in general office work involving multiple totals, and also for cash registering. When cash drawers are added to the Series P300 machine, by using the two totals, you can get the totals of individual sales during a specified period and also a gross total of sales at the end of the period. Amounts indexed on the keyboard may be added simultaneously in both registers by using the motor bar, or they may be added in either of the registers independently by using specified control keys.

SERIES P400 MACHINES

The Series P400 adding machines has two registers and ADDS and SUBTRACTS. It accumulates one or two sets of figures, including both add and subtract items. When you put the register selection lever in the A or B position (designation of two registers), you get a single accumulation of figures. If you put the register selection lever (fig. 6-2) in the AB position, you get SIMULTANEOUS accumulation of ADDED or SUBTRACTED amounts. Plus or minus totals of these accumulations are printed on the tape and are identified by A or B and the proper total symbol.

A. Date and normal lever
B. Subtotal key
C. Total key
D. Non-add key
E. Repeat key
F. Register selector lever
G. Error key

91.140X

Figure 6-2.—Series P400 adding machine.

When the number, date and normal lever (A) (fig. 6-2) is located in the extreme right position and the register selection normalizing key (latch down control key located below total

key) is released, items accumulate alternately as the register selection lever automatically shifts back and forth. This feature enables the operator of the machine to list quantity and value, old and new balances, debits and credits, tax and amount, and so forth.

If you place the date and normal lever in the center (split) position (with the register selection normalizing key latched down and the register selection lever in the AB position), you can list figures on both sides of the keyboard and add them simultaneously in both registers. This feature provides a means of converting the machine into a FOUR-TOTAL machine for obtaining GROUP totals and GRAND totals of listed amounts.

SERIES P600 MACHINES

The Series P600 adding machine is a bookkeeping machine used for posting accounts payable and accounts receivable. A line proof total and also a net proof total may be obtained in the accounts payable or accounts receivable applications. The line proof total (from register A) provides the difference between the old and new balance of an account. This should be the same as the net total of the charges and credits posted to the account during one posting operation. The net proof total (from register B) provides a net total of all the charges from credits posted during the complete posting run. This should be the same as the net total of the pre-list of all the items posted.

A red ribbon lift mechanism on this machine enables the operator to print selected information in RED. The feed carriage (15" length) can be opened and closed manually for easy insertion of forms from the front. The carriage also has a form aligning table, adjustable form guide, and a plastic journal holder.

DISASSEMBLY AND CLEANING

The disassembly of all office machines, including adding machines, should be accomplished in a logical and sequential manner, and in accordance with the manufacturer's instructions (in technical manuals). Always remove the most accessible part first and take precautions to safeguard it. This is a prime consideration in the disassembly of any office machine, but particularly those with small or delicate parts.

There are so many parts in an adding machine, and the procedure for disassembling them is so precise, that space in this chapter does not allow a detailed discussion of disassembly. Follow the instructions of the manufacturer for a specific machine relative to disassembly and you will have no difficulty. With experience, the procedure for disassembling an adding machine will be easy.

The cleaning process for adding machines is essentially the same as for typewriters. All parts which are not damaged by recommended solvents and cleaning solutions can be left on the machine when it is submerged in cleaning solution, or put in a cleaning machine. Electrical and rubber parts are damaged by cleaning agents and must NOT be put in solutions used for cleaning metal parts. Clean rubber parts with a clean cloth and denatured alcohol.

MECHANISMS AND ADJUSTMENTS

The adding machine mechanisms discussed in this section are for the Burroughs Series P400 machine. This machine was selected because it has two registers, adds and subtracts, and is used by the Navy for many purposes. Adjustments for each mechanism are given at the end of the discussion of that mechanism.

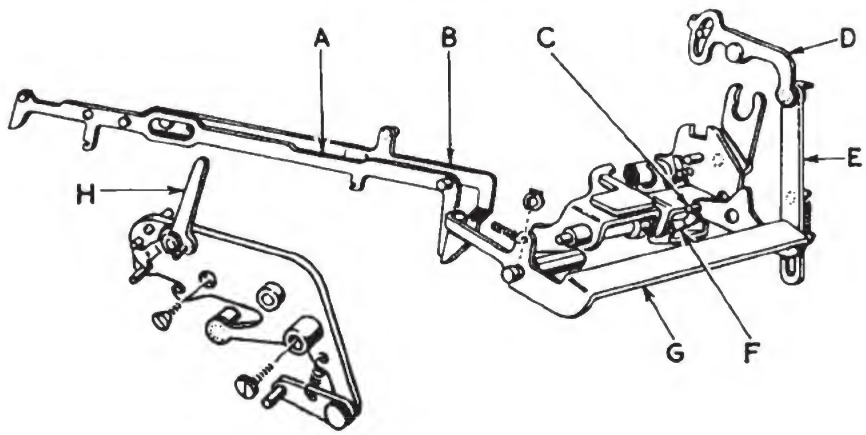
FORM SPACING MECHANISM

The form spacing mechanism for the Series P400 machine is illustrated in figure 6-3. It permits the selection of 5/6" spacing (jump totals) during total operations, so that figures will advance beyond the cutting edge of the tear-off blade in narrow carriages.

When the jump total spacing lever (disabling) is in the rear position, depression of the TOTAL key moves the slide to the limit bail (actuated by the total and subtotal keys) rearward and the slide to the limit bail (actuated by the total key) forward to remove them from the path of the limit bail.

During the forward stroke of a total operation, the limit bail actuating arm moves out of the path of a stud on the limit bail to allow spring tension to rock the limit bail. Rocking of this bail through the space control link, the space control arm, and a bellcrank permits the paper feed pawl to engage the platen ratchet gear to space the form 5/6 inch.

When the disabling lever is positioned to permit 5/6" spacing during total operations, the two slides to the limit bail restrict action



A. Slide to limit bail G (actuated by total key)
B. Slide to limit bail G (actuated by total and subtotal keys)
C. Stud on bail G
D. Space control arm
E. Space control link
F. Actuating arm for bail G
G. Bail
H. Jump total spacing lever

91.141X

Figure 6-3.—Form spacing mechanism.

of the bail to prevent 5/6" spacing during listing operations—the slide which is actuated by the total and subtotal keys prevents 5/6" spacing during listing operations, and the slide which is actuated by the total key prevents 5/6" spacing during subtotal operations.

If the disabling lever is in its forward position, spacing during total operations is the same as that indicated by the adjustable form space control.

The following adjustments of the form spacing mechanism are necessary to prevent 5/6" spacing:

1. When the jump total spacing lever is moved forward, its hooked portion should have minimum clearance under the lip of the space control arm. To make proper adjustment, move or form the limit bail.

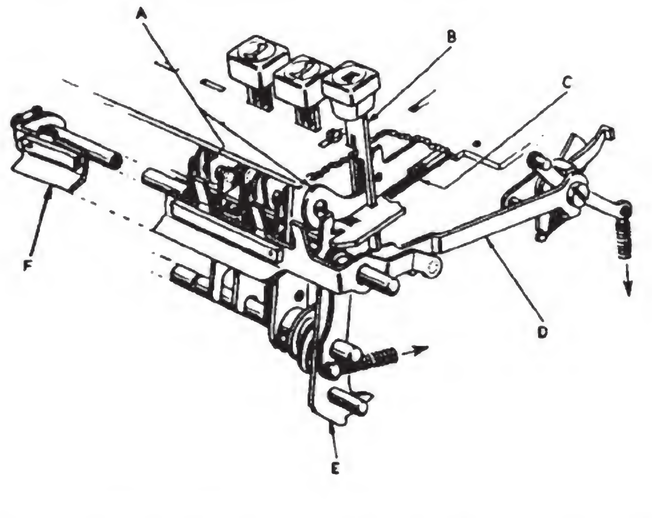
2. When the machine is operating with the total key depressed and the jump total spacing lever is in its forward position, the lip on the forward end of the space control arm should have full hold on the hooked portion of the jump total spacing lever. To adjust, bend the lip on the forward portion of the space control arm.

To prevent 5/6" spacing during listing when the adjustable form space lever is in a position other than No. 5, make certain that the lip on the fore part of the limit bail has minimum clearance over the step on the rear portions of the slides actuated by the total key and the total and subtotal keys. To adjust, bend the front portion of the limit bail.

ERROR KEY MECHANISM

Study the error key mechanism illustrated in figure 6-4. This mechanism enables the operator to release incorrectly indexed listing keys, operating keys, and motor bars before the machine is operated.

When the error key is depressed, it lowers the error arm and rocks the key release bail, which (by means of projections on its upper portion) moves the locking strip rearward to clear the key stems. The released keys are then returned to their rest positions by the key restorer springs. Rocking of the key release bail also swings the locking strip rocker arm, which (through its lowest stud's contact with the lip on the foremost part of the latching arm for plus



A. Locking strip
B. Error key stem
C. Key stem restorer spring
D. Error arm
E. Rocker arm controlling locking strip in column 0
F. Bail which releases keys from error key

91.142X

Figure 6-4.—Error key mechanism.

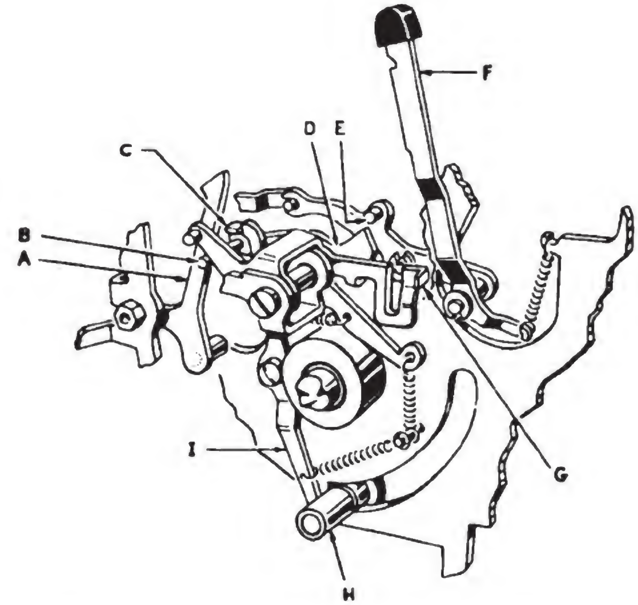
and minus bars) moves the latches on the latching arm for plus and minus bars clear of the steps on the motor bars. Restoration of the motor bars is then provided by spring tension.

All keys should be free when you fully depress the error key. If adjustments are necessary for all columns, open or close the slot in the error arm. To adjust individual columns, bend the upright projections on the key release bail.

The lips on the latching arm must clear the steps on the motor bars when the error key is fully depressed, to ensure release of the motor bars when the error key is depressed. To make proper adjustment, bend the upright projection on the right end of the key release bail.

REPEAT KEY INTERLOCK

When the register selector control lever (F, fig. 6-5) is unlatched, the register selector lever automatically alternates from the A to the B position, and vice versa, on each machine operation and depression of the repeat key is blocked. Stud E (fig. 6-5) is now positioned over the back part of arm D, preventing it from rocking, and



A. Repeat arm
B. Stud on arm D
C. Lip on arm D which is engaged by latch I
D. Arm which blocks travel of stud E
E. Stud which limits on arm D.
F. Register selector control lever
G. Lip which blocks forward movement of index bar in column 0
H. Roller on secondary mechanism
I. Latch which holds arm D in the raised position

91.143X

Figure 6-5.—Repeat key interlock.

also from blocking the depression of the repeat key.

If the register selector lever control key (F) is latched down when you depress the repeat key, the action lowers the repeat arm, which (through the stud on arm D) positions the rear portion of arm D in the path of the stud (E) that limits on arm D to prevent release of the control key.

To prevent the printing of symbols, depress the repeat key. When you do this, arm D rocks and lowers lip C (fig. 6-5) to allow the hooked portion of latch I to move over lip C as roller H moves rearward during the forward stroke. Latch I then holds lip G in the path of the projection on the underside of the index bar in column O in case the repeat key is released before the operation is completed during repeat operation of added items.

Near the end of the return stroke, the forward movement of a roll (H) on the secondary mechanism rocks the latch which holds arm D in the raised position out of engagement with the lip on arm D to allow lip G to move down and out of the path of the underside of the index bar in column O.

To ensure DISENGAGEMENT of latch I from lip C, there should be a clearance of approximately .010" between lip C and the upper portion of latch I. You can make an adjustment to get this amount of clearance by bending the lowest part of latch I.

When the TOTAL keys of the Series P400 adding machine are held depressed, repeat total operations are blocked. A handle break also occurs then to prevent complementary totals. This safeguard is necessary when the register selector lever automatically shifts to or from a register with a minus amount when the other register has a plus amount.

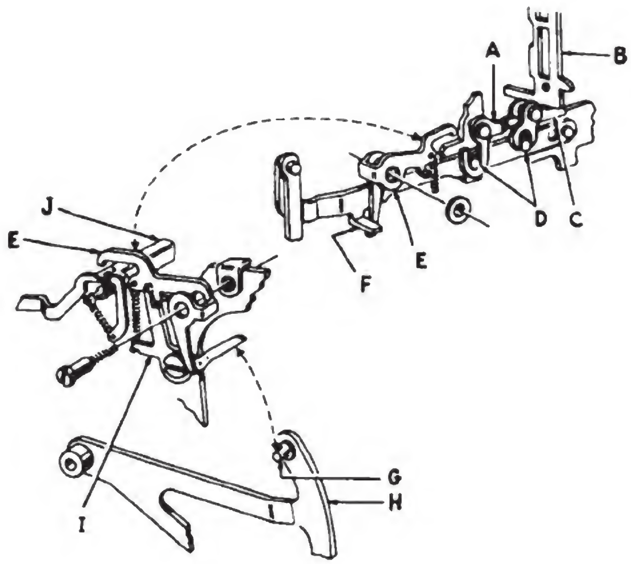
As the total keys are depressed (B, fig. 6-6), bellcrank A or C, which actuates the slide (F) that controls the interlock (E) (blocks movement of the channel bail), moves the slide to the rear to allow interlock E to be pulled down into engagement with latch I.

During a forward stroke of the machine as segment arm H moves upward, stud G releases latch I from interlock E and permits interlock E to be pulled down into engagement with the channel bail.

If the total keys are held depressed manually during a machine operation, the slide which controls the interlock remains to the rear and the interlock (E) remains engaged with the channel bail to cause a handle break.

To ensure proper latching of the interlock, there should be a clearance of approximately .010" between the lip of the interlock and the stop on the latch which limits the interlock. Bend the tail of the interlock TO or FROM the lip of the slide (F) to get the correct amount of clearance.

To ensure engagement of the interlock with the channel bail (J), during a forward stroke (total key depressed), the latch (I) which limits the interlock (E) should be moved far enough by the stud on the segment arm to release the interlock and to permit it to engage the channel bail. To make proper adjustment, bend the inner tail of the latch which limits the interlock (E) to get earlier contact with the stud on the segment arm.



A. Bellcrank which actuates slide F
B. Subtotal key stem
C. Bellcrank which actuates slide F
D. Stud on slide F
E. Interlock which blocks movement of channel bail J
F. Slide which controls interlock E
G. Stud on segment arm H
H. Segment arm
I. Latch which limits interlock E
J. Channel bail

91.144X

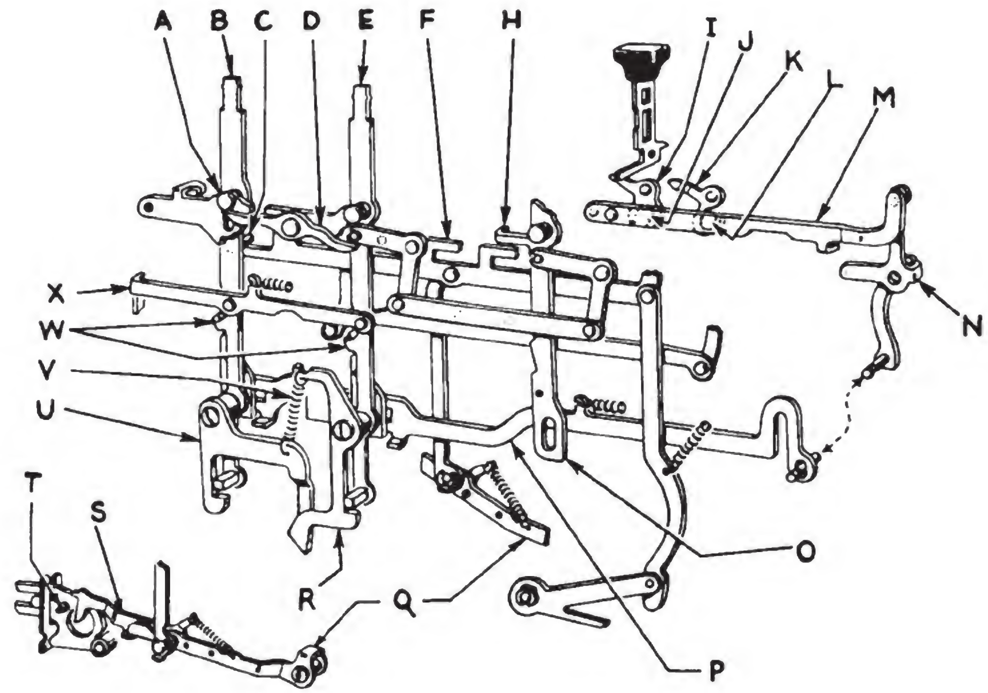
Figure 6-6.—Blocking of repeat total operations.

MOTOR BAR AND CONTROL KEY INTERLOCKS

Simultaneous depression of operation control keys and/or motor bars is prevented by interlocks which stop machine lockup and wrong addition. Study illustration 6-7 as you follow the discussion of these interlocks.

When a total key is depressed, it causes bellcrank K to rock and to move slide M rearward. Slide M then rocks link N and moves interlock P forward to locate its formed ears under minus bar B and plus bar E to block depression.

Depression of the minus bar (B) or the plus bar (E) positions the formed ear on the lowest part of the depressed motor bar into the path of the interlock, thereby preventing forward movement of the interlock.



A. Stud on minus bar which actuates interlock D
B. Minus motor bar
C. Stud (on minus bar) which lowers the intermediate bar (F)
D. Interlock which prevents simultaneous depression of plus and minus motor bars
E. Plus motor bar assembly
F. Intermediate motor bar
H. Lip (on motor bar assembly) which actuates intermediate bar F
I. Bellcrank which actuates slide M
J. Stud on slide M
K. Bellcrank which actuates slide M
L. Stud on slide M
M. Slide which actuates link N
N. Link connecting slide M and interlock P
O. Rear plus bar
P. Interlock which prevents depression of motor bars when total keys are depressed
Q. Arm which actuates interlock S
R. Interlock which prevents snap depression of the plus bar during minus operations
S. Interlock which limits rearward movement of stud T
T. Stud on key restoring arm
U. Interlock which prevents snap depression of minus bar during plus operations
V. Spring which actuates interlocks R and U
W. Lips on latching arm X
X. Latching arm for plus and minus bars

91.145X

Figure 6-7.—Motor bar and control key interlocks.

Operation of the machine, and a subsequent lock by partial depression of the non-add key, is prevented by the interlock (S) which limits rearward movement of the stud on the key restoring arm.

Another interlock (U) prevents a snap depression of the minus motor bar during the last part of a plus operation to prevent the minus wheels from being partially shifted while a relay carry takes place. If allowed, partial shifting could cause the wheels to be moved out of alignment with the carry racks and perhaps cause either a loss of carry or a lockup.

Interlock R (fig. 6-7) prevents a snap depression of the plus bar during the last part of a minus operation. If it were possible to snap the plus bar when a minus carry originating in column 6 or 7 is taking place, a loss of carry or a lockup could result, as follows: A plus operation could start, causing the wheels to be moved out of alignment with the carry racks before the carry could be completed to column 13, then back to column 1 through the automatic carry one bail and over to the column in which the carry originated.

Adjustments of the motor bar and control key interlocks are as follows:

1. To ensure actuation of the indexing mechanisms by the motor bars, before tripping the clutch, the clutch should be tripped from slow depression of the minus bar after it has been latched down by the lips on the latching arm. To adjust, bend the foremost finger on the intermediate motor bar.

2. To make certain that the indexing mechanisms are actuated by the operation control keys, before tripping the clutch, the clutch should be tripped from slow depression of specified operation control keys after the keys have been latched down. To make proper adjustment, bend the finger on the intermediate bar which the operation control key contacts.

3. In order to safeguard against simultaneous depression of a motor bar and an operation control key, there should be a clearance of about .010" between the rear surface of the lowest portion of the motor bars (B & E) and the formed ears of interlock P when the motor bars are slowly depressed. To adjust, bend the U form on the rear portion of the interlock.

4. To avoid misoperation or a locked machine from a partial depression of the repeat key during plus operations, there should be a clearance of the stud on the key restoring arm over the upper point of the interlock (S) which limits rearward motion of the stud during a machine operation with either a motor bar or an operation control key latched down. To adjust, bend the forward portion of the arm which actuates the interlock.

5. To ensure release of the motor bars during machine operations, lips (latches) on the latching arm for plus and minus bars should be moved far enough forward to clear the steps on the motor bars when the machine is operated. To make proper adjustment, bend the lip on the forward portion of the latching arm.

SYMBOL INDEXING MECHANISMS

Various functions of registers A and B are identified by symbols printed to the right of printed amounts. Symbol type is positioned in columns 0 and 00 on adding racks controlled by symbol index bars F and E, respectively. Positioning of the index bars is controlled by the operation control keys, register selector lever, or a motor bar.

Symbol printing in column 00 is controlled by the position of lever B (fig. 6-8). The three

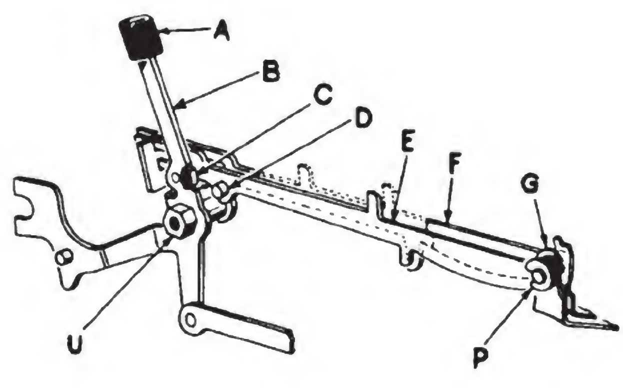


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Figure 6-8.—Register A and/or B accumulation.

positions of register selector lever B determine the location of stud C which, in turn, acts as a limit for the forward travel of index bar E (column 00) through stud D.

The index bar in column 0 is blocked by depression of the plus motor bar K (fig. 6-9). When this bar is depressed, it causes a lowering of lip M into the path of projection N, link R, and stud L. The lowering of lip M into the path of

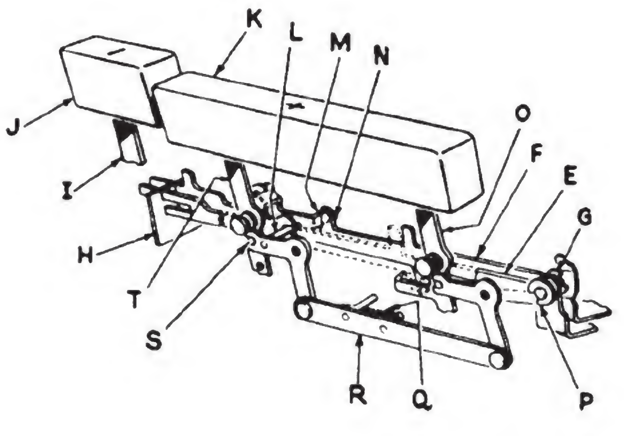

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Figure 6-9.—Symbol index blocking by plus motor bar.

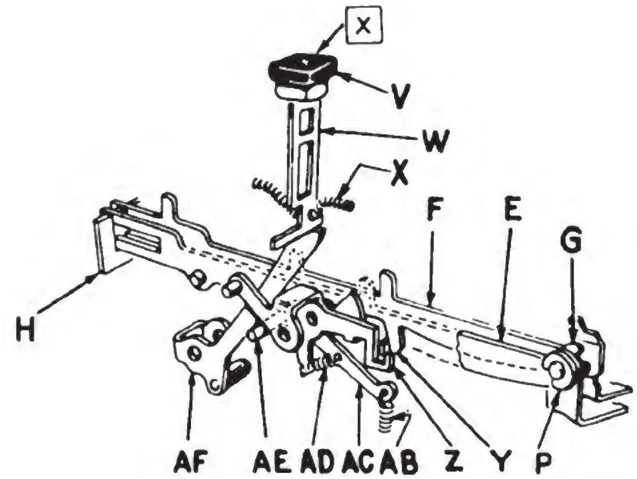

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Figure 6-11.—Prevention of symbol printing in column 0.

projection N prevents the index bar (F) for column 0 from moving forward, thereby allowing printing of the register indexing symbol ONLY.

If the minus motor bar (J, fig. 6-10) is depressed, it causes a lowering of lip AJ into the path of projection AG, permitting index bar F for column 0 to move to a designated position for printing the minus symbol.

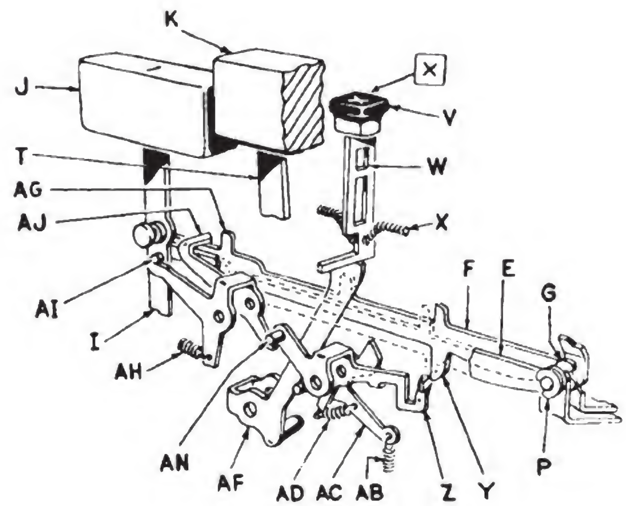

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Figure 6-12.—Symbol printing in column 0.

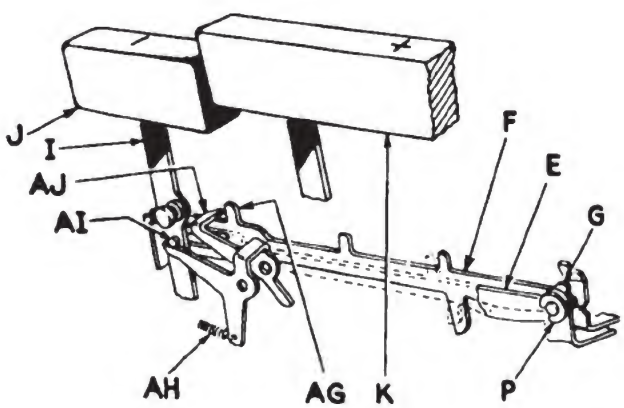

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Figure 6-10.—Minus symbol indexing (column 0).

When the repeat key (W, fig. 6-11) lowers arm AF, the arm then raises lip Z into the path of projection Y to block forward movement of the index bar for column 0.

Simultaneous depression of the minus motor bar (J, fig. 6-12) and the repeat key stem (W) lowers lip AJ into the path of projection AG. At the same time, the rear tail of part AJ lowers lip Z out of the path of projection Y, permitting the positioning of index bar F (column 0) for printing the minus symbol.

The NON-ADD key limits the index bar in column 0 for printing and blocks the index bar in column 00. Study figure 6-13. If the non-add key stem (AK) is depressed, it blocks the forward movement of the index bar (E for column 00) at point AM. During the forward stroke

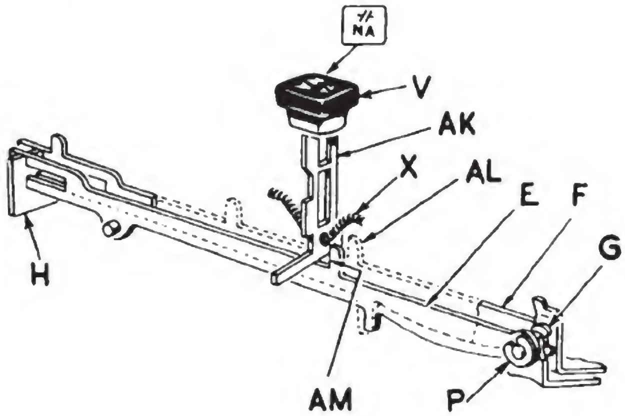

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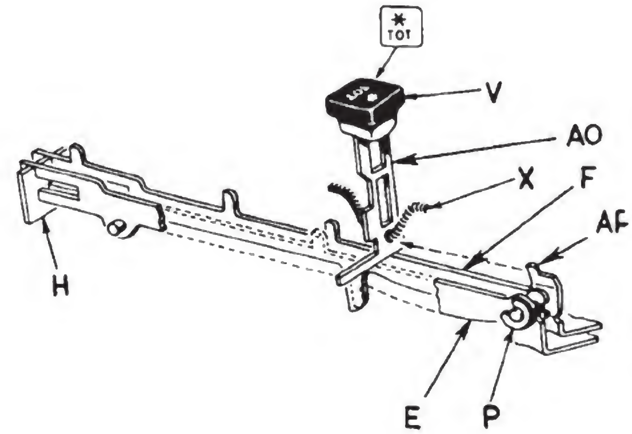
Figure 6-13.—Action of non-add key on index bars in columns 0 and 00.



91.152X
Figure 6-14.—Limitation of index bar in column 0 by the total key.

of an operation, index bar F for column 0 moves forward until projection AL limits against the rear part of key AK to print a specified symbol.

When the total key stem (AO, fig. 6-14) is depressed, it positions the lowest part of the key in the path of projection AP, allowing the index bar for column 0 to travel forward until it is limited by the depressed key for printing a specified symbol.

Depression of the subtotal key stem (AO, fig. 6-15) places the lowest part of the key behind projection AP, permitting index bar F to travel forward until point AQ is stopped by guide H for printing a specified symbol.

When a minus balance is indexed, slide AT (fig. 6-16) is positioned forward to locate its upright projection under the total key stem (AO). Depression of key stem AO lowers the forward portion of slide AT, which (in turn) lowers slide AV to position lip AR in the path of projection AP. During a forward stroke, travel of index bar F for printing a specified symbol is limited by lip AR's limiting against the rear portion of key stem AO.

In the minus balance position, slide AT (fig. 6-17) is positioned forward, locating its upright projection under keystem AO. If key AO is depressed, the action causes a lowering of the front part of slide AT which then lowers slide AV to place lip AR in front of key stem AO and in the path of projection AP.

During the forward stroke of an operation, travel of index bar F for printing a specified symbol is limited by slide AV's limiting against stud AW.

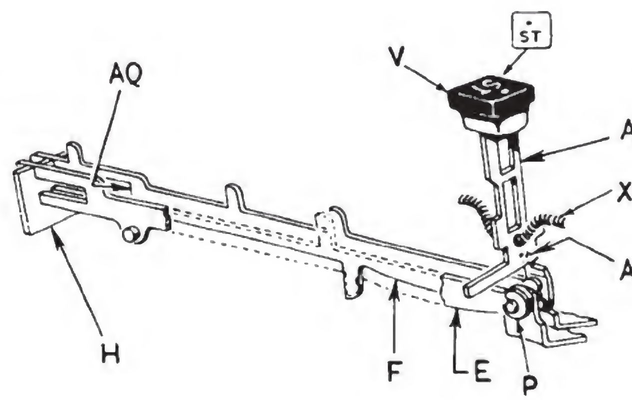


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Figure 6-15.—Limitation of index bar in column 0 by guide H.

Depression of the TOTAL key stem (AO, fig. 6-18) rocks bellcrank AY, which moves slide AZ rearward to rock arm BI down. As arm BI moves downward, it contacts stud BH to lower link BG. Then link BG raises lip BC into the path of projection BB to limit travel of index bar E for column 00 for printing symbol "A".

The following checks and adjustments of indexing mechanisms are important:

1. To ensure proper location of the adding rack in column 00 (to permit proper aligning shaft engagement when the register selector lever is in the AB position), the adding rack in column 00 should be so positioned that it permits

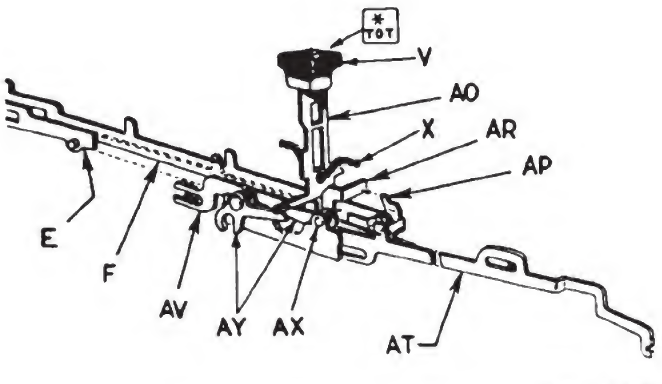

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Figure 6-16.—Limitation of forward travel of index bar in column 0 by lip on slide AV.

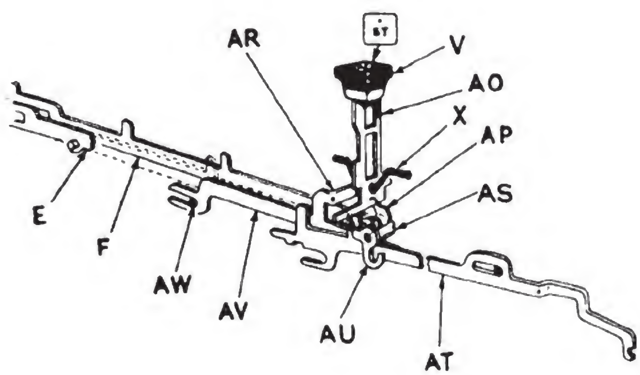

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Figure 6-17.—Control of travel of index bar in column 0 by slide AV.

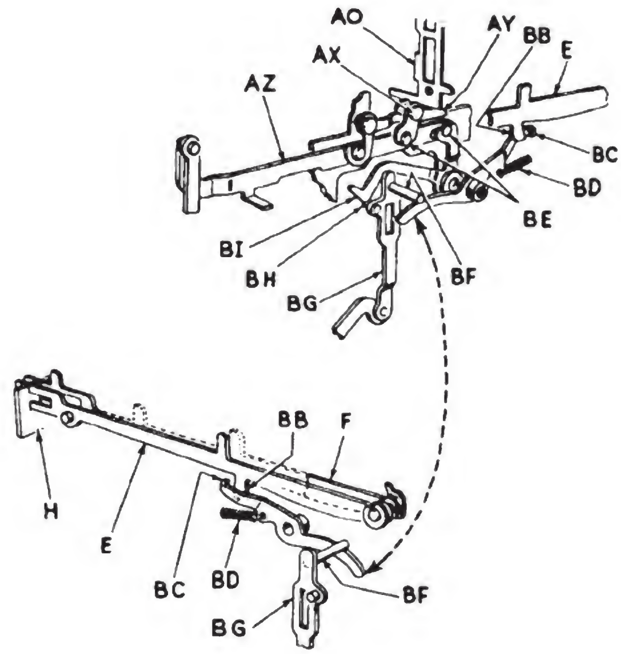

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Figure 6-18.—Printing of symbol A during plus and minus totals with register selection lever at AB.

the aligning shaft to move into the tooth spaces of the adding rack with minimum upward or downward movement of the adding rack. To get this type of adjustment, weave the upper right end of the adding rack.

2. To safeguard against the printing of a symbol in column 0 when the PLUS motor bar is depressed, there should be minimum clearance between lip M and projection N (fig. 6-9) when the plus motor bar is slowly depressed. To adjust properly, bend lip M.

3. To prevent the printing of a symbol in column 0 during REPEAT-PLUS operations, there should be minimum (non-binding) clearance between lip Z (fig. 6-11) and projection Y when lip Z is manually raised. To adjust for proper clearance, spread or close the U slot in the arm which contains lip Z.

4. To ensure blocking of the index bar in column 0 when the repeat key is not fully depressed, the lower edge of lip Z (fig. 6-11) must be aligned FLUSH with the LOWER edge of projection Y when key stem W (fig. 6-11) is manually held depressed. To make this adjustment, bend lip Z up or down, as necessary.

5. To make certain that the forward movement of index bar E (fig. 6-13) is blocked by key stem AK, there must be minimum clearance between the rear part of key AK and the front edge of projection AM when key AK is slowly depressed. To adjust, bend the lowest portion of key stem AK.

6. Projection AP (fig. 6-14) must have full lateral hold on key stem AO during the forward stroke of a plus total operation. Make proper adjustment by weaving the adding rack (column 0) up and down. This adjustment is necessary to get stoppage of the forward travel of the index bar F (column 0) during plus totals.

7. The adding rack in column 0 must be correctly located to permit proper aligning shaft engagement during minus balance totals, with the machine in the minus balance position and during the forward stroke (total key depressed).

To get proper location of this adding rack, lip AR (fig. 6-16) must limit travel of the adding rack to allow the aligning shaft to move into the tooth spaces of the rack with minimum upward or downward movement. To make proper adjustment, check slide AV for freedom of action and then bend lip AR forward or rearward, as necessary.

8. The adding rack in column 0 must also be correctly located to permit proper aligning shaft engagement during minus balance subtotals (machine in minus balance position, subtotal key depressed). Stud AW (fig. 6-17) must therefore limit the forward travel of slide AV as necessary in order to limit travel of the adding rack in column 0 to give the aligning shaft an opportunity to move into the tooth spaces of the adding rack with minimum upward or downward movement of the adding rack. Adjust by bending lip AR forward or rearward, as necessary, and then re-check for the condition stated in No. 7.

TOTAL KEYS INDEX HAMMERBLOCK MECHANISM

Printing in specified columns is controlled by the total keys to prevent the printing of folio numbers with totals when the number, split and normal lever is in the number position (extreme left).

When a total or subtotal key stem is depressed, the action rocks bellcrank C or E (fig. 6-19) which moves slide D rearward, causing bellcrank A to rock through lip K. Bellcrank A then rocks finger B downward to raise the rear portion of bail J, allowing the actuating bail spring (I) to rock the indexing hammer latch bail (F). The fingers of bail F are therefore rocked into the paths of rolls on the hammer latches (G and H), thereby preventing the latches from contacting the hammers as the racks move up.

Make the following adjustment on the hammerblock mechanism: To ensure full movement of bail F when a total key is depressed, there should be minimum clearance between the lowest finger on bail J and the roll on the right end of bail F when either the total or subtotal key is latched depressed. To get proper clearance, bend the lip on bellcrank A.

INTERMEDIATE INDEXING MECHANISM

The intermediate indexing mechanism positions type bars in a position to correspond to keys indexed on the keyboard. The adding racks, assembled within frame Q with collars J, O, and P (fig. 6-20) carry type bars F and are controlled by movement of the index bars (R), which are limited by their upright projections stopped by key stems 1 through 8. When the No. 9 key is depressed, the racks move upward and are limited in movement by the limit bail for adding racks in the No. 9 position. When no keys are depressed, forward movement of the index bars is prevented at cipher position by the foot of the cipher stops.

The sector limit plate (L) limits downward movement of the adding racks to prevent their overthrow, which could result in: (1) a point-to-point lock of the adding pinions and the adding racks during a handle break with the total key depressed; and (2) over addition, caused by tripping off carries when adding figure 9.

In addition to the slots provided in the aligning shaft, guides I and S guide the adding racks to maintain their alignment with the adding pinions.

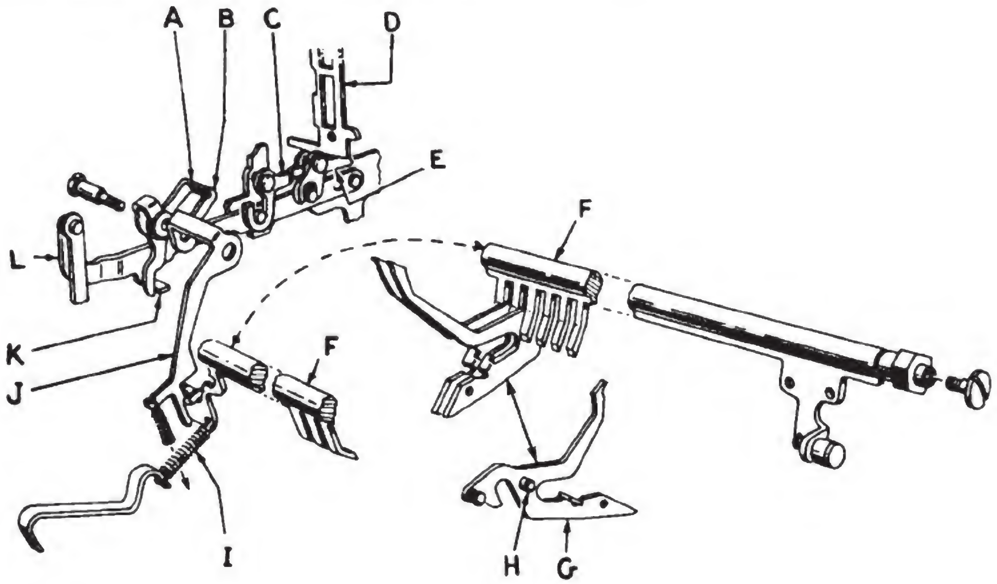
There are two braces which prevent excessive upward movement of the adding racks in columns 1, 2, and 8 through 13 during machine operations in which these adding racks are active. See C and G in figure 6-20. Excessive upward movement of these adding racks may prevent full engagement of the aligning shaft with the adding racks, causing uneven printing.

There are six tests and adjustments which you should make on the intermediate indexing mechanism, as follows:

1. In order that you may be able to get the correct starting point for making the next two adjustments, position the upright, right-angled arm of the retaining bail for guide S and limit plate L to its full limit toward the adding racks. Have the machine resting on the rear edges of the accumulating frames when you make this adjustment, by loosening screw N and positioning bail K.

2. Be sure that guide S limits against the left side frame, so that you will have correct alignment of the adding racks with the adding pinions. To make proper adjustment, loosen the two screws (M) and position the guide.

3. Make certain that plate L has a snug, non-binding limit against the lowest part of the adding racks when the handle is in the normal position. This limitation is essential to safeguard against a point-to-point lock of the adding pinions and the adding racks and tripping of carries when adding figure 9. Make proper



A. Bellcrank which actuates bail J
B. Finger of bail J.
C. Bellcrank which actuates slide L
D. Total key stem.
E. Bellcrank which actuates slide L
F. Bail which indexes hammer latches (G)
G. Hammer latch
H. Roll on hammer latch
I. Spring which actuates bail F
J. Bail which holds bail F in normal position
K. Lip on slide L
L. Slide which actuates bellcrank A

91.157X

Figure 6-19.—Total keys index hammer block mechanism.

adjustment by loosening the two screws (M) and positioning plate L.

4. Brace G must be held rigid in a fixed position. In order to hold it in this manner, bend the lips on its upper portion, as necessary.

5. To guard against excessive upward movement of the adding racks in columns 1 and 2, you must have a snug, non-binding fit between the fingers on brace G and the clips (A) which retain the index bars. Adjust as necessary by bending the fingers.

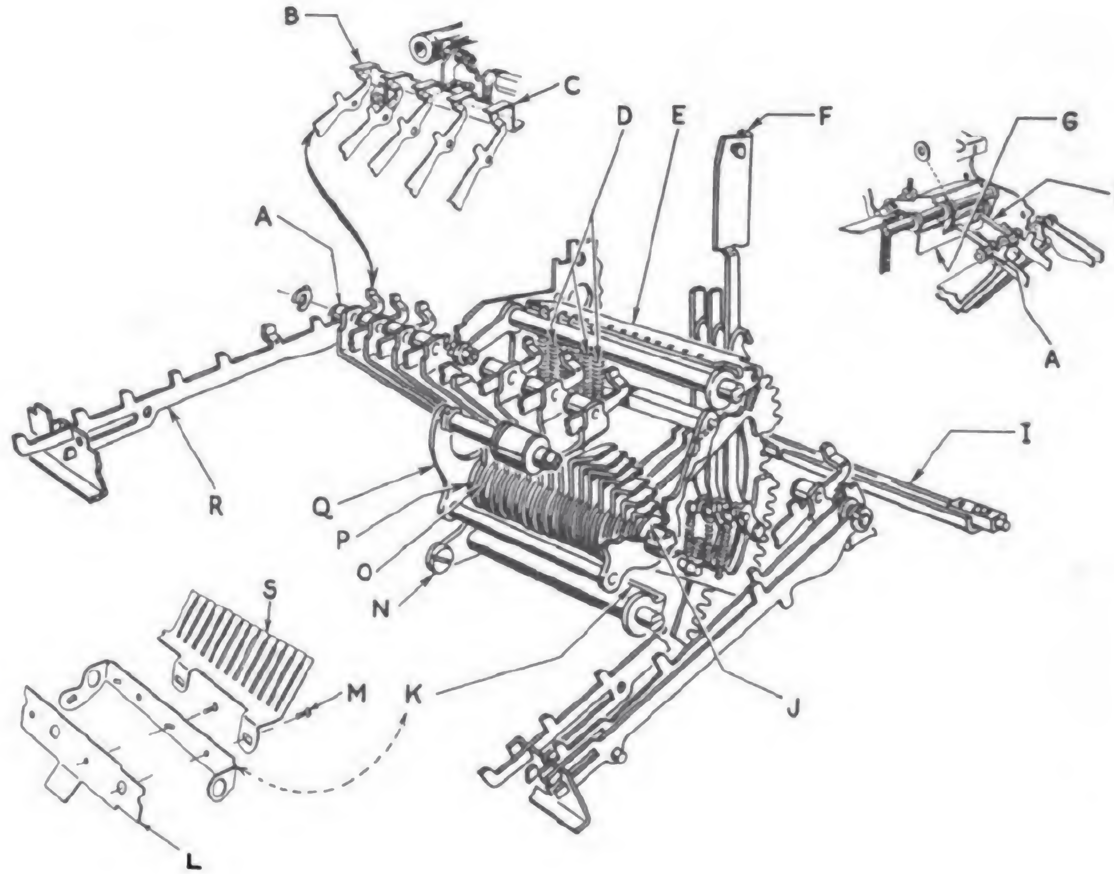
6. Prevent excessive upward movement of the adding racks in columns 8 through 13 by bending the fingers on brace C, as required, to get a snug, non-binding fit between the fingers on brace C and the No. 8 projections of the index bars, and also during the return stroke with the No. 9 listing keys indexed in columns 8 through 13. The No. 8 projections of the index bars must clear beneath the fingers on brace C to permit correct positioning of the cipher stops.

REGISTER SELECTOR MECHANISM

The register selector mechanism for the Series P400 Burroughs adding machine is shown in figure 6-21.

Automatic alternating selection of register A or register B (when the register selector lever control key in position 7-0 is released) permits accumulation in alternate registers while you are listing consecutively. This feature provides a means by which old and new balances, debits and credits, amounts, and so forth, may be listed during the same run.

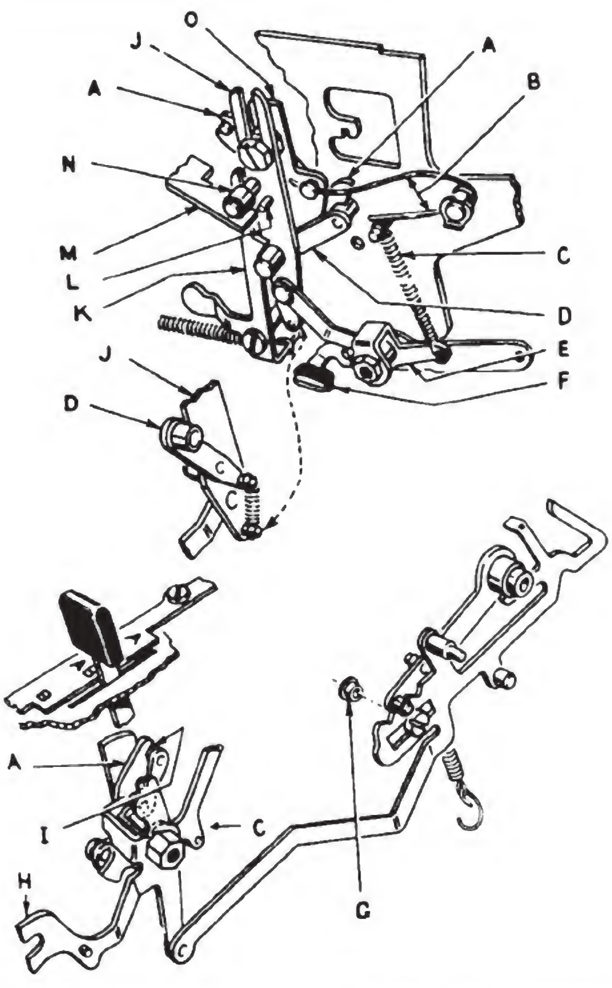
During the early part of the forward stroke of a machine operation, with the register selector control key in the released position, as arm M moves away from roller N, arm E and spring C pull link J down. Downward movement of link J positions the roll on arm D against the lowest part of the spear point of pawl A and, at the same time, limits stud L on the step of latch



A. Index bar (R) retaining clip
B. Finger on brace C
C. Brace which prevents excessive upward movement of adding racks
D. Adding rack springs
E. Limit bail for adding racks in the No. 9 position
F. Type bar
G. Brace which prevents excessive upward movement of adding racks
H. Finger on brace G
I. Guide for adding racks
J. Space collar
K. Bail which retains guide S and limits plate L
L. Plate which limits downward movement of adding racks
M. Screw which secures guide S
N. Screw which holds bail K to the left side frame
O. Space collar
P. Space collar
Q. Restoring frame
R. Index bar
S. Guide for adding racks

91.158X

Figure 6-20.—Intermediate indexing mechanism.



A. Pawl which reverses the position of the register selector lever
B. Spring which restores slide O
C. Spring which pulls arm E
D. Actuating pawl (A) arm
E. Arm which pulls link J
F. Cushioned limit for arm E
G. Bushing for register selector lever assembly
H. Register selector lever
I. Stud which connects the register selector to pawl A
J. Link which arm E actuates
K. Latch which prevents shifting of lever H during handle breaks
L. Limit stud for link J
M. Arm which restores link J
N. Roll
O. Slide which prevents automatic shifting of the register selector lever

91.159X

Figure 6-21.—Register selector mechanism.

K to safeguard against automatic shifting of the register selector lever (H) if a handle break occurs.

As the forward stroke continues, the front part of the dashpot actuating arm assembly rocks latch K away from stud L to allow link J to move farther down and the roller on arm D to be indexed on the opposite side of the spear point of pawl A.

Near the end of the return stroke, arm M engages roll N, which moves the roller on arm D into engagement with pawl A to reverse the position of lever H through stud I.

When the register selector control key (AA, fig. 6-22) is depressed, it prevents automatic shifting of the register selector lever, thereby permitting the operator to select registers when listing PLUS and MINUS amounts.

Depression of the control key lowers the slide (O) which prevents automatic shifting of the register selector lever. The lowering of slide O moves roller AD out of the pocket in pawl A to permit manual shifting of the register selector lever.

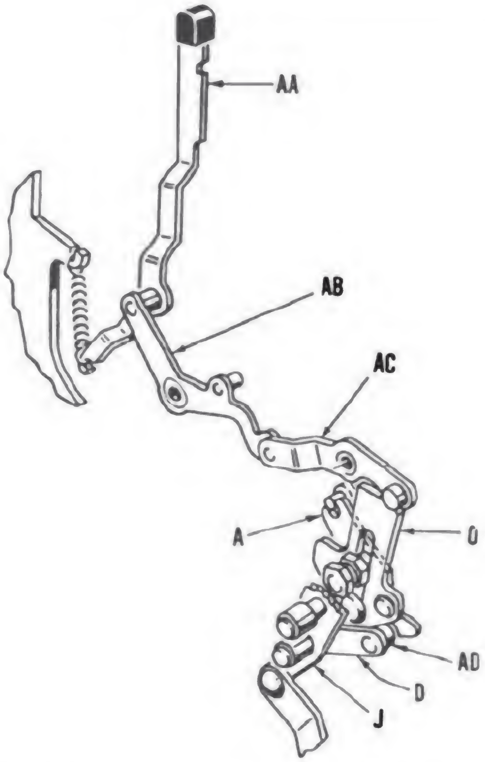
During the forward stroke of a machine operation (with key AA latched depressed as link J moves downward), roller AD is carried down the incline of slide O just short of the spear point of slide O, thus leaving arm D in an inactive position.

Adjustments on the register selector lever just discussed are:

1. Align lever H (fig. 6-21) centrally in the slot of the upper keyboard plate, and see that it is free on bushing G. This adjustment can be made by bending lever H, and it is necessary to permit free movement of the register selector lever.

2. Bend the front portion of lever H up or down, as necessary, to ensure that the forked end of lever H is not in the path of the lower shaft of the key restoring rack assembly during the forward stroke of an operation (with lever H in any of the three operating positions). This adjustment prevents a handle break when the register selector lever is correctly located in any position, and also when it is partially shifted.

3. Bend the offset tail of latch K to get correct timing for the release of link assembly J. The offset tail of latch K should be aligned centrally with the foremost part of the dashpot actuating arm assembly. Latch K should also be moved from under stud L immediately after the full stroke pawl enters the first notch of the



AA. Register selector lever control key
AB. Arm which connects key AA to arm AC
AC. Arm which connects arm AB to slide O
O. Slide which prevents automatic shifting of the register selector lever
AD. Roll
D. Arm which actuates pawl A
J. Link
A. Pawl which reverses the position of the register selector lever

91.160X

Figure 6-22.—Register selector lever control key mechanism.

full stroke segment during the forward stroke of a machine operation.

4. To safeguard against a false normal limit of the machine's main drive assembly, there must be a clearance of approximately .015" between roll N and arm M (fig. 6-21) when link J is held up manually. You can make proper adjustment by loosening the brace under arm M and bending arm M up or down. Then re-position the brace as required to get a snug fit to the underside of arm M.

5. In order to have equal alternating throw of the register selector lever, with the register selector lever control key released and the machine operated slowly during the return stroke, lever H should have equal alternating throw in the slot of the upper keyboard plate. Adjust by bending the upper arm of lever H to stud I.

6. Arm D should be so adjusted that it reverses positions. To adjust, loosen the two screws which retain limit arm F and raise or lower the back portion of arm F. Link J should have enough downward movement during the forward stroke of an operation to permit the roll on arm D to clear the bottom of slide O by about .010 inch.

7. In order to ensure full resotration of slide O, it must move to its highest position when key AA is slowly released. Adjust slide O as necessary to give it freedom, and also check the condition of the slide restoration spring.

REGISTER SELECTOR LEVER INTERLOCK

The register selector lever interlock blocks movement of the lever when the total keys are depressed. Study figure 6-23.

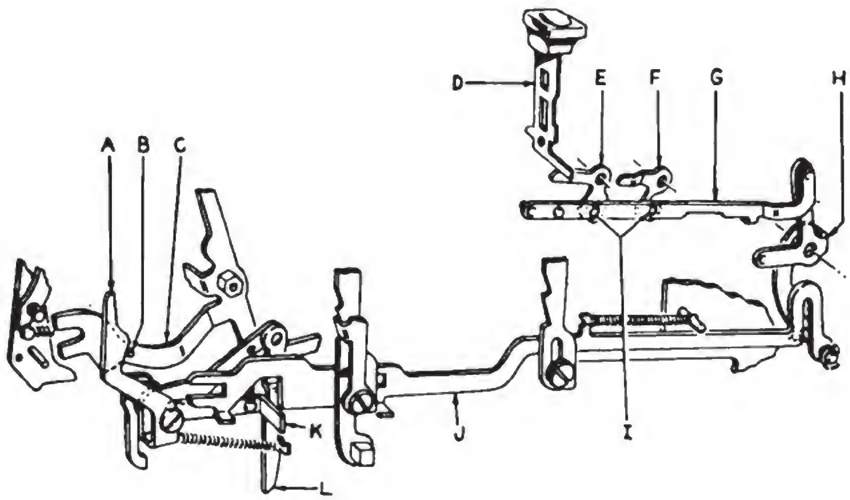
When there is a minus balance in a selected register, interlock J safeguards the printing of complements by preventing the shifting of the register selector lever to the opposite register position after the total keys have been depressed far enough to be latched down without tripping the drive clutch.

When the total keys are depressed, slide G is moved toward the rear by bellcrank E or F and stud I. Then slide G moves interlock J forward into the path of lip K to block the shifting of the register selector lever.

REGISTER MESHING CONTROLS

Register meshing controls engage and disengage the adding pinions of registers A and/or B with the adding tracks.

Engagement and disengagement of registers A and B adding pinions with the adding racks is controlled by segment G (fig. 6-24), which (through its connection to the dashpot arm assembly by link I) receives an oscillating action during each machine operation. Studs H and K on segment G actuate register A, and studs D and F on segment G actuate register B.



A. Arm which blocks movement of lever C
B. Stud on lever C
C. Register selector lever
D. Total key stem
F. Bellcrank which actuates slide G
F. Bellcrank which actuates slide G
G. Slide which rocks arm H
H. Arm which connects slide G to interlock J
I. Studs which connect bellcranks E and F to slide G
J. Interlock which blocks movement of lip K
K. Lip on assembly L
L. Arm which blocks movement of lever C

91.161X

Figure 6-23.—Register selector lever interlock.

Positioning of lever AG (fig. 6-25) in one of its three positions (A, AB, or B) gives register selection.

As segment G moves downward at the beginning of the return stroke, stud H engages the upper pawl (E), which (by means of assemblies J and L) engages the adding pinions of register A with the adding racks. Near the end of the return stroke, stud K engages the forward finger of the upper assembly (L, fig. 6-24) to disengage the adding pinions from the adding racks.

When lever AG is moved into position A, it causes roller AF to rock arm AC which (through contact with a stud in arm AD) moves AD rearward to raise the lower pawl (E) out of the path of stud F, thus making register B inactive.

Engagement of stud F with the lower pawl at the beginning of the return stroke, and engagement of stud D with the fore finger of the lower assembly, engages and disengages the adding pinions of register B with the adding racks in the manner described for register A.

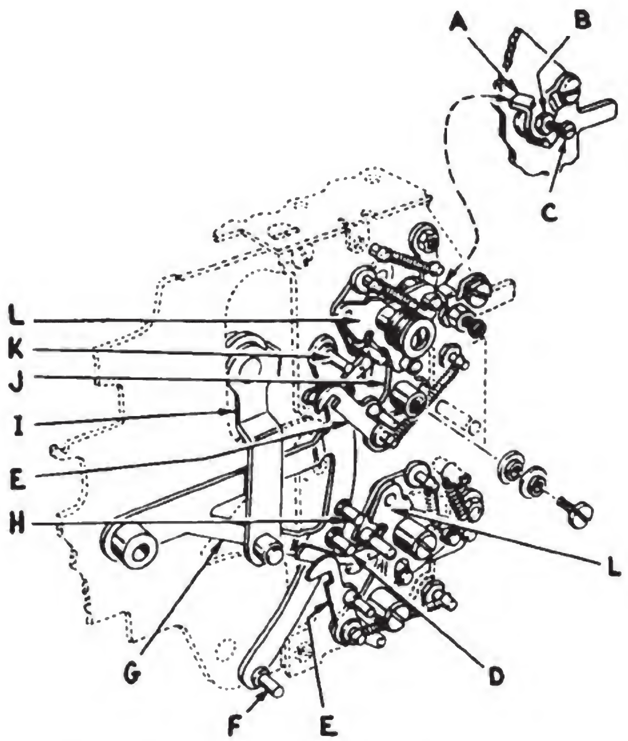
Movement of lever AG into the B position (fig. 6-26) causes roller AF to rock arm AC which moves AB rearward to raise the lower pawl out of the path of stud H, thus preventing action by register A.

If lever AG is located in the AB position (fig. 6-27), the upper and lower pawls remain at normal and are engaged during the return stroke of a machine operation by studs H and F, respectively, to engage simultaneously the adding pinions of registers A and B with the adding racks.

Disengagement of the adding pinions of both registers from the adding racks is accomplished in the same manner as described for registers A and B.

Make the following adjustments on the register meshing controls:

1. Check for a clearance of approximately .005" between stud K and the forward finger of the upper assembly, and also between stud D and the forward finger of the lower assembly. This



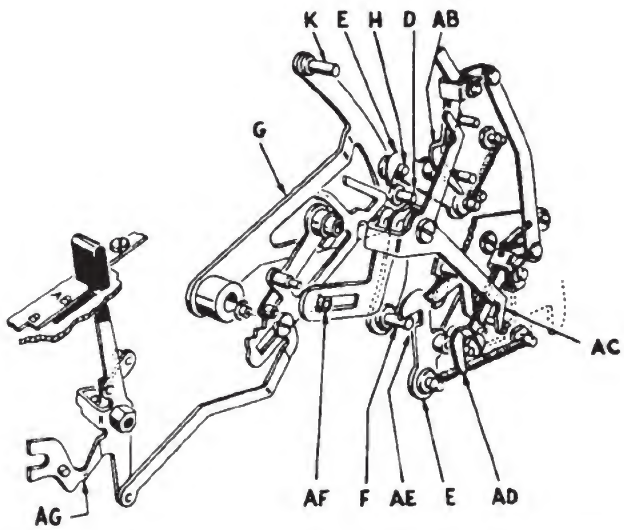
A. Retainer for adjusting screw (C)
B. Lock nut
C. Adjusting screw
D. Stud which moves register B out of mesh
E. Listing pawls for registers A and B
F. Stud which engages the lower pawl (E)
G. Segment which controls registers A and B
H. Stud which engages upper pawl F
I. Link which connects segment G to the dashpot assembly
J. Rocker arm which contains listing pawl (E) for register A
K. Stud which moves register A out of mesh
L. Rocker arm which contains the total pawl for register A

91.162X
Figure 6-24.—Register meshing controls.

amount of clearance is essential to prevent a false limit of segment G. To adjust properly, bend the forward fingers of the upper and lower assemblies, as necessary.

2. Test the lateral hold of studs K and D on the forward fingers of the upper and lower assemblies. During the return stroke of an operation, the hold of the studs on these fingers should be FULL in order to move registers A and B out of mesh (with lever AG in the AB position). Adjust as necessary by bending the forward fingers of the upper and lower assemblies.

3. When lever AG is in the A position, there should be about 1/32" clearance between stud F and the lower pawl at point AE (fig. 6-25)



91.163X
Figure 6-25.—Meshing and unmeshing of register A during a return stroke.

as segment G moves downward during the return stroke of an operation. This amount of clearance is necessary in order to prevent the meshing of register A during a return stroke when lever AG is in the B position. Adjust by bending the lowest portion of arm AC.

4. To safeguard against the meshing of register A during the return stroke of an operation when lever AG is in the B position, there should be a clearance of about 1/32" between stud H and the upper pawl at point AA (fig. 6-26) as segment G moves down during a return stroke. To get proper clearance, bend the uppermost finger of arm AC.

NON-ADD MECHANISM

The non-add key on the Series P400 adding machine permits printing of descriptive figures without accumulation in registers A and B. When the key is depressed, the accumulator listing

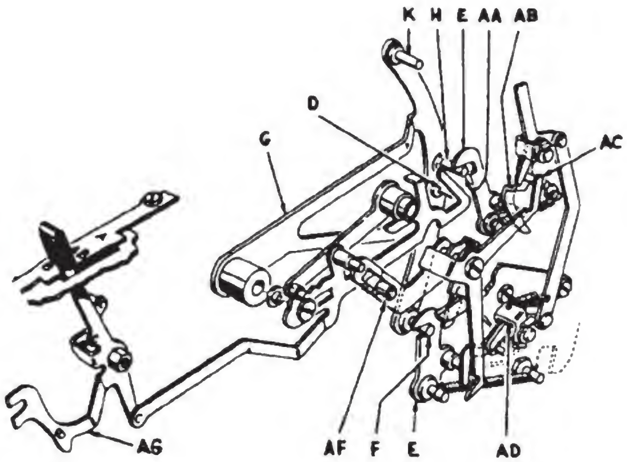


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Figure 6-26.—Meshing and unmeshing of register B during a return stroke.

pawls are disengaged to prevent meshing of the accumulator pinions with the adding racks during the return stroke.

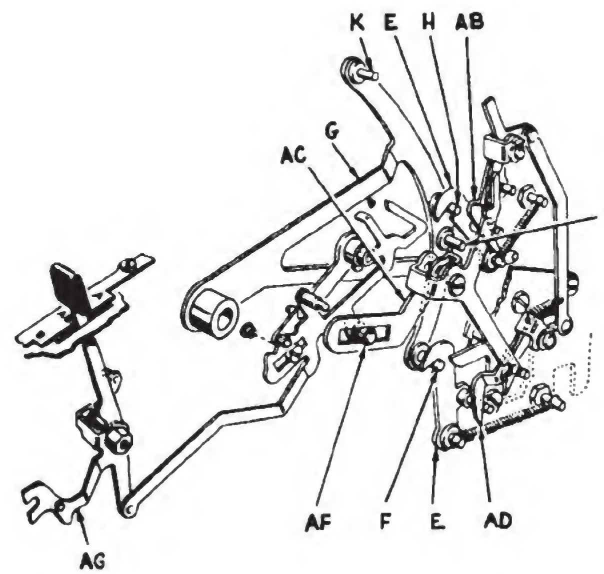

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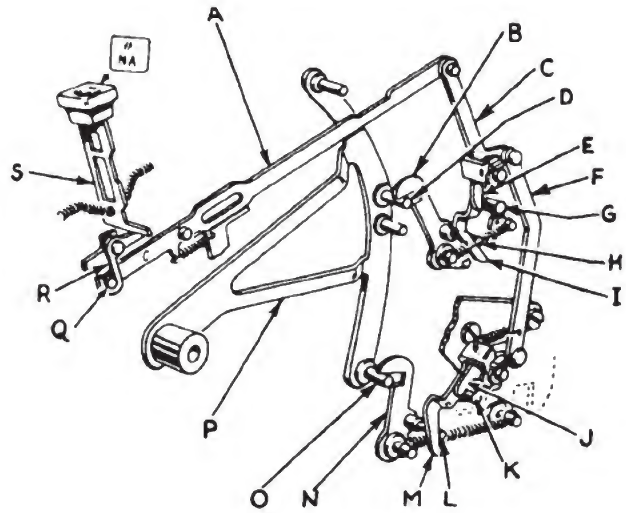
Figure 6-27.—Meshing and unmeshing of registers A and B when the register selector lever is in the AB position.

Study figure 6-28. Depression of the non-add key stem (S) moves slide A forward through bellcrank R and stud Q to rock the rocker arm assembly. Rocking of this assembly raises



A. Slide which actuates the rocker arm assembly
B. Listing pawl for register A
C. Rocker arm assembly
D. Stud which engages pawl B
E. Finger (on rocker arm assembly) which contacts stud G
F. Link on the rocker arm assembly (C)
G. Stud on arm I
H. Stud on listing pawl B
I. Arm which contacts stud H to raise pawl B
J. Finger on rocker arm assembly (C)
K. Stud on arm M
L. Stud on listing pawl N
M. Arm which raises listing pawl N
N. Listing pawl for register B
O. Stud (on segment P) which engages listing pawl N
P. Segment which controls register accumulators
Q. Stud which connects bellcrank R to slide A
R. Bellcrank which actuates slide A
S. Non-add key stem

91.166X
Figure 6-28.—Non-add mechanism.

register A's listing pawl out of the path of the stud which engages the pawl (to non-add register A), through finger E, stud G, finger I, and stud H. Rocking of the rocker arm assembly also raises register B's listing pawl (N) out of the path of stud O (to non-add register B), through link F, finger J, stud K, finger M, and stud L.

Tests and adjustments which you should make on the non-add mechanism consist of the following: To prevent the adding of amounts in registers A and B during non-add operations, with the non-add key depressed, there should be no less than .010" clearance between stud D and pawl B (also between stud O and pawl N) as segment P moves downward during a return stroke. Make proper adjustment by bending the finger on the rocker arm (E) to increase the clearance between stud D and pawl B, and by bending finger J to increase the clearance between stud O and pawl N.

SUBTRACT MECHANISM

The subtract mechanism of the Series P400 adding machine is shown in figure 6-29. Study the nomenclature carefully.

When amounts are being subtracted in either register A or B, the upper pinions of each register are shifted to the left and the lower pinions are shifted to the right. Because the accumulator pinions are meshed with the adding racks at the beginning of a return stroke, they are turned in the OPPOSITE direction when subtracting. This shifting of the accumulator pinions is indexed from the subtract motor bar or from the total keys when a minus balance is in the machine.

Shifting of Accumulator Pinions

Depression of the minus motor bars (fig. 6-29) rocks assembly AC; and this rocking lowers links AB and AE, which rock the bellcranks to locate spear points G to the right of arm F.

As the accumulator pinions move into mesh with the adding racks during the beginning of a return stroke, the arms which rock the bellcranks move down against the inclined surfaces on the left side of the spear points on the bellcranks to increase the rocking of the bellcranks. This increased movement of the bellcranks pivots the rocker arms (I) to shift the pinion shafts (H), and to locate the upper pinions to the left and the lower pinions to the right. The rocker arms are then held in their respective positions by detent springs.

When the rocker arms are pivoted to shift the pinion shafts, the upper finger of the bracket assembly (K) is pulled down into the path of the upper stud of the detent assembly which actuates links M and S.

Near the end of a return stroke, as assembly L moves to the rear, the upper finger of assembly K contacts the upper stud on assembly N, thereby moving link M rearward to raise latch W off the lip of carry rack U. Bail V, actuated only when a relay carry takes place beyond the capacity of the machine, keeps carry rack U latched at this time.

As the minus bar returns to its normal position, the bellcranks which pivot the rocker arms are positioned by springs to index shifting of the pinions to the add position.

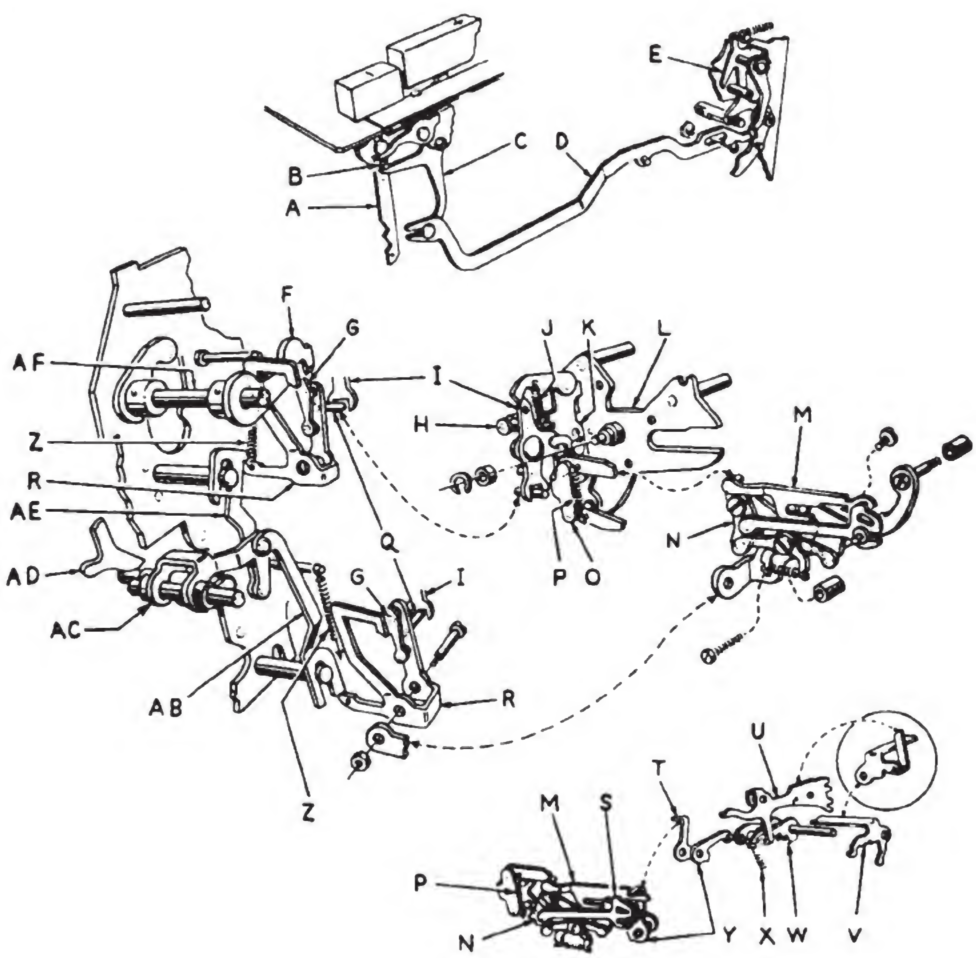
Tests and Adjustments

Make the following tests and adjustments on the subtract mechanism, as necessary:

1. Eliminate sideplay in the upper and lower shaft assemblies by loosening the lock nut (B, fig. 6-24), and turning the adjusting screw.
2. Bend the hooked parts of the bellcranks as necessary in order to get a clearance of about .010" with the left side of their rocker arms. Make this adjustment with the upper pinions in the ADD position, springs Z unhooked, and studs Q held against the right side of the forked portion of arm I. This adjustment prevents partial shifting of the pinions when subtraction takes place.
3. With registers A and B in the ADD position, bend the lower arms of the bellcranks (R) as necessary to get a clearance of .005" of the bellcranks under links AB and AE when bail E is manually held completely rearward.
4. To ensure correct indexing of the subtract mechanism, bend the outward arm of bail E as necessary to have the high point of the camming portion of the bail on the center of the stud on assembly AC when the minus bar is depressed.
5. Adjust the forward edge of the inner arm bail (E) as required in order to have it limit against the post in the side frame when the minus motor bar is in the normal position. Adjust by bending the lower finger on the bellcrank which actuates bail E.
6. Bend the arms which rock the bellcranks (R) to the extent necessary to have equal clearance of the arms on either side of the spear points (G) when the adding pinions are fully meshed with the adding racks during the return stroke of minus and plus operations.

REGISTER CARRY MECHANISM

The acccumulator consists of the upper register (A) and the lower register (B). The



- A. Minus motor bar
- B. Stud on minus bar which actuates bellcrank C
- C. Bellcrank which connects minus bar A to subtract arm D
- D. Subtract arm to actuating bail E
- E. Bail which rocks assembly AC
- F. Arm which rocks bellcrank R
- G. Spear point finger assembled to bellcrank R
- H. Adding pinion shaft
- I. Rocker arm which shifts adding pinion shaft
- J. Detent spring which holds rocker arm
- K. Bracket
- L. Right side plate of accumulator section
- M. Link which rocks bail Y
- N. Detent assembly which actuates links M and S
- O. Lower part of bracket K
- P. Spring which holds fingers on bracket K in position
- Q. Stud to pivot rocker arms (I)
- R. Bellcrank to pivot rocker arms
- S. Link which rocks Bail Y
- T. Lip on bail Y
- U. Carry rack in column one
- V. Automatic one carry bail
- W. Carry rack latch in column one
- X. Spring for latch W
- Y. Bail which actuates latch W
- Z. Spring which restores link assembly AB
- AB. Link which actuates the lower bellcrank (R)
- AC. Bail which actuates link AB
- AD. Lower part of bail E
- AE. Link which actuates the upper bellcrank
- AF. Accumulator control shaft for register A

91.167X

Figure 6-29.—Subtract mechanism.

registers are identical in construction, operate independently, and produce direct MINUS totals.

Each register consists of two sets of intermeshed pinions, upper (add) and lower (subtract). See figure 6-30. Study the nomenclature carefully. Then concentrate on the information in the following sections, which give a further breakdown of the carry mechanism.

Cross-sliding action of the adding and subtracting pinions permits only one set (add or subtract) to be meshed with the adding racks during listing and total operations. The pinions meshed with carry racks J (fig. 6-30) when the accumulator wheels are normal are called intermediate wheels. The pinions aligned with either carry pawls B or C are known as the active wheels.

During adding and plus total operations, the lower sets of pinions slide to the left for meshing with the adding racks. During subtracting and minus total operations, the upper pinions slide to the left for meshing with the adding racks.

Plus Carry Mechanism

The plus carry mechanism is illustrated in figure 6-31. An initial plus carry is produced when the wide tooth of the upper pinion (L, turned clockwise) rocks the carry pawl (B), which (through its forked connection with carry pawl (C) moves the lower portion of pawl C rearward to have it latched.

A plus carry is completed when the lip of the lowest part of carry pawl C rocks latch H as the accumulator moves out of mesh with the adding racks. The rocking of latch H raises its rear step clear of the lip on the carry rack (J), allowing spring G to rock rack J upward. Rack J then rotates the lower pinion (L) counterclockwise. The lower pinion, in turn, rotates the upper pinion clockwise to advance it one point.

Minus Carry Mechanism

The minus part of the carry mechanism is shown in figure 6-32. An initial minus carry is produced when the wide tooth of the lower pinion rocks the carry pawl toward the rear to latch it. A minus carry is completed in the same manner as a plus carry, except that the upper pinion (meshed with the carry rack) is rotated counterclockwise. The upper pinion then rotates the lower pinion clockwise to advance it one point.

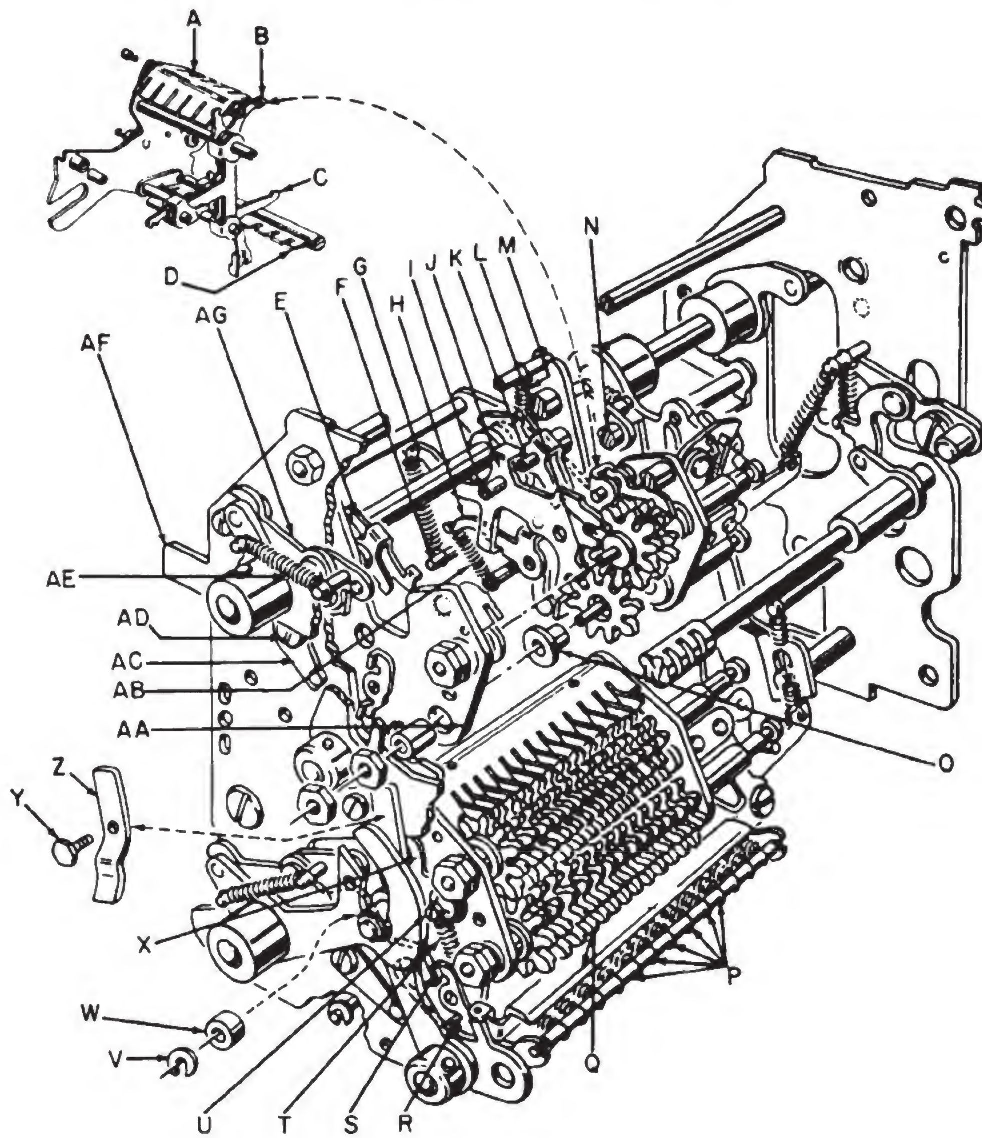
Resetting of carry pawls B and C takes place when carry rack J moves upward (fig. 6-31), raising latch E to allow spring P to pull the carry pawls back to their normal positions.

Carry racks J are reset when assembly AG (fig. 6-30) moves the accumulator into mesh with the adding racks. As AG moves forward, shaft N moves down and contacts the upper flat surface of the carry racks to move them down to permit the rear step on latches H to engage the lip of the carry racks.

Tests and Adjustments

The following adjustments of the carry mechanism of a Series P400 adding machine are essential:

1. Bend the carry pawls (B) as necessary to give them approximately .005" over-all side play, and then centrally align them in the slots of guide A.
2. Bend carry pawls C as required to give them about .005" over-all sideplay, and align them centrally in the slots of guide D. They must also be FREE on the studs in the upper pawls.
3. Open or close the U form of latches E to the extent required to keep sideplay at .010 inch. This amount of sideplay ensures correct normal and initial carry positions for pawls B and C.
4. To ensure free movement and proper alignment of the carry racks, make certain that their sideplay is not over .010 inch.
5. Open or close the U form of latches H to give them between .010" and .015" of sideplay. These latches must have proper alignment and freedom of movement.
6. The upper and lower adding pinions must have FREE movement in order that they may spin. When their bushings become worn and interfere with movement, replace them.
7. Weave the bail which holds the adding pinions in position as required to safeguard against a point-to-point locking of the adding pinions with either the adding or carrying racks.
8. Bend the lips of the bail which holds the adding pinions in position to the extent necessary to give the upper edge of the bail about .010" clearance below the point of the teeth of the lower pinions when they are meshed with either the adding or carrying racks.
9. As a precaution against over and under additions, bend the lip on the lowest part of the lower carry pawl to ensure NOT LESS THAN



A. Guide for carry pawl (upper)
B. Upper carry pawl
C. Lower carry pawl
D. Guide for lower carry pawl
E. Latch for carry pawl
F. Spring shaft
G. Carry rack spring
H. Carry rack latch
I. Carry rack retaining shaft
J. Carry rack
K. Shaft which retains carry pawl latches
L. Adding pinion
M. Spring for carry pawl latch
N. Carry rack reset shaft
O. Bushing for adding pinions
P. Lower carry pawl springs
Q. Bail which holds adding pinions in position when they mesh and unmesh
R. Lower lip on bail Q
S. Upper lip on bail Q
T. Spring which actuates bail Q
U. Spring anchor screw
V. Clip which holds roll W in position
W. Roll
X. Shaft retainer
Y. Screw
Z. Guide plate which prevents excessive side play in the accumulator section
AA. Left side plate of accumulator section
AB. Carry rack latch spring
AC. Shaft retainer
AD. Screw for shaft retainer
AE. Spring which holds link AG in position
AF. Left side frame
AG. Link on the carry rack reset shaft (N)

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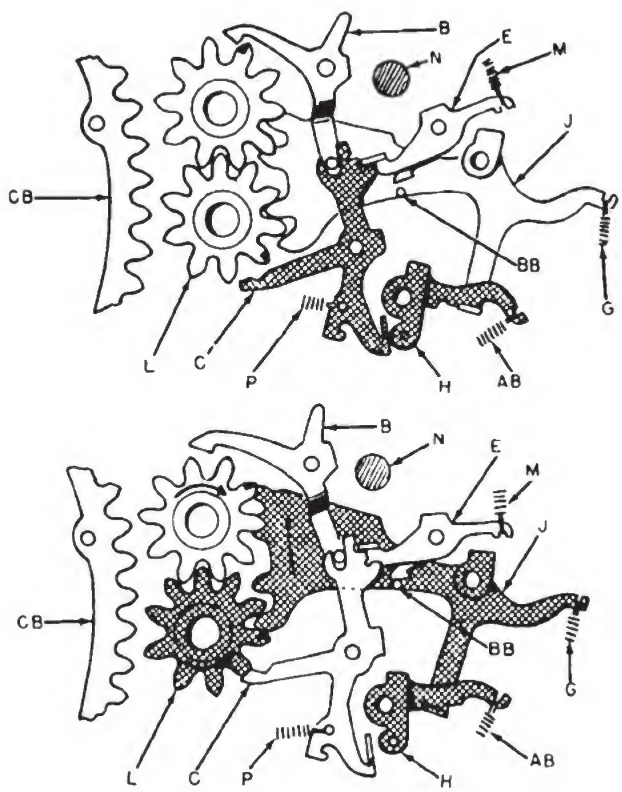
Figure 6-30.—Carry mechanism for registers A and B.



91.169X
Figure 6-31.—Plus carry mechanism.

.008" and NO MORE THAN .012" clearance between the lip on the lowest part of the lower pawl and the lower leg of the carry rack latch, when the accumulator is in its normal position.

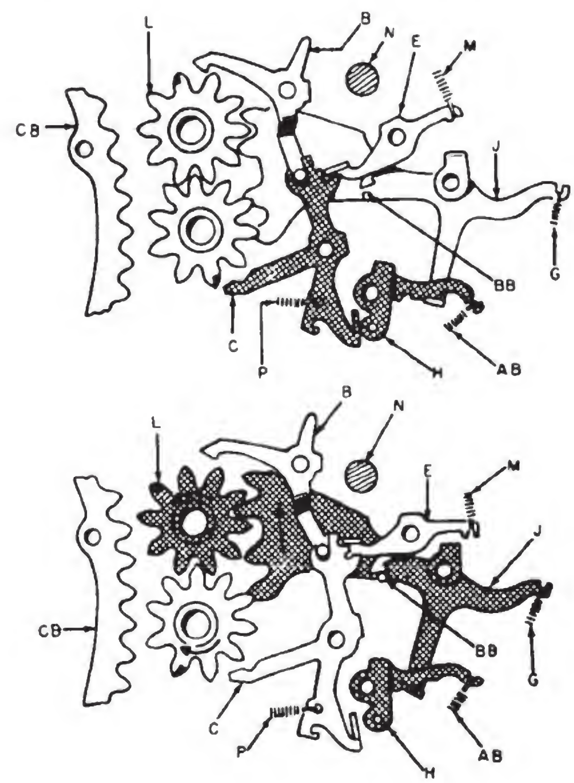
MINUS BALANCE MECHANISM

Study the minus balance mechanism of the Series P400 adding machine in figure 6-33. This mechanism advances the first upper or lower sliding pinion one point and permits slides A and/or B to be indexed for plus or minus totals when added or subtracted amounts change the nature of the accumulated totals from plus to minus, or vice versa.

In adding machines which have 13 columns of adding capacity, a carry in the first column (automatic one) is produced in a manner similar to that of a conventional carry; that is, by releasing carry rack K, by lifting latch J through links Q or R, and by rocking bail F by carry pawl H. A carry in the first column of machines with less than 13 columns of adding capacity is produced in like manner, except that bail F is rocked by carry pawl H's rocking of latch I.

During a subtract operation, as the accumulator moves out of mesh, link R moves to the rear and engages lip N to rock bail L and to lift latch J out of engagement with the carry rack in column one (K). If the amount being subtracted exceeds added amounts accumulated during previous operations, the capacity of the accumulator is exceeded by the relay carry. This condition causes the wide tooth of the last lower adding pinion to rock pawl H, which then rocks bail F out of engagement with carry rack K, permitting this rack to be pulled up into the carried position to advance the first lower adding pinion one point.

Indexing of the minus balance mechanism in registers A and/or B is accomplished through upward movement of carry rack K, which rocks the arm (M) to lower links Q and R. This arm then moves link R down, causing link Q to move up and detent P to reverse its position. As P reverses position, it swings bail S or T to rock arm U or V forward, allowing springs (W) to pull slides A and/or B forward to locate their upright projections under the total keys. When the total keys are depressed, slide A or B is



91.170X
Figure 6-32.—Minus carry mechanism.

lowered and link E is indexed into the subtract position through the rocking of the bellcrank which actuates link E.

As the accumulator moves out of mesh during the first added-amount operation following a minus-balance total operation, link Q raises latch J through bail L. When the amount being added exceeds the capacity of the upper adding pinions, the relay carry causes the wide tooth of the last upper pinion to rock carry pawl G, which causes carry pawl H to rock bail F out of engagement with carry rack K to permit carry rack K to be pulled up and to advance the first upper adding pinion one point. At the same time, carry rack K moves link Q down to reverse the position of detent P, which then rocks bail S or T to move slide A or B back to the normal position to normalize the minus balance mechanism.

Adjustments on the minus balance mechanism are as follows:

1. Weave bail F as necessary to have the steps on its right and left ends parallel to the lips on the carry rack in the first and last columns.

2. Weave bails S and/or T to the extent required to have a clearance of .010" between the front ends of the slots in slides A and B and the stud containing screw C when the stud in detent arm O is seated in the rear pocket of detent P.

3. Bend the forked portion of latch J as necessary to give it a safe hold on the stud of bail L. This adjustment is necessary in order to have latch J raised in preparation of an automatic one.

4. To ensure maximum upward travel of carry rack K, tilt the stud on the rear part of arm M as required to get a clearance of approximately .010" between the stud and its rear portion and brace L1 as carry rack K moves up into a carried position.

TOTAL TIMING MECHANISM

The total timing mechanism of a Series P400 adding machine safeguards against complementary results by preventing the depression of the TOTAL and SUBTOTAL keys until slides A and B (fig. 6-33) have assumed their correct positions during plus and minus balance operations. Refer to the mechanism illustrated in figure 6-34 as you study its operation.

During a forward stroke, slide F is moved to the rear by roll E and is latched in this position by lip I. As slide F moves rearward, stud J is placed in the rear part of the internal cam in the timing arm (N), and stud K is moved away from tail L to permit spring C to raise lip A into the path of slide B to block depression of the total and subtotal keys.

Lip I is disengaged from slide F at the end of the return stroke, by roll E's contact with finger D. This disengagement permits spring H to pull slide F forward, but the forward movement of the slide is retarded by stud J as it travels in the internal cam in the timing arm. If it is necessary that the forward movement of slide F be retarded further, weights M, O, and P may be added.

As slide F returns to normal, stud K contacts tail L to lower lip A out of the path of slide B, permitting depression of the total keys.

Tests and adjustments for the total timing mechanism are as follows:

1. To prevent lip A's interference with the normal forward movement of slide B, bend tail L to or from stud K to the extent necessary to get a clearance of about .010" between the upper edge of lip A and the lower edge of slide B after slide B moves forward from a depression of either total key.

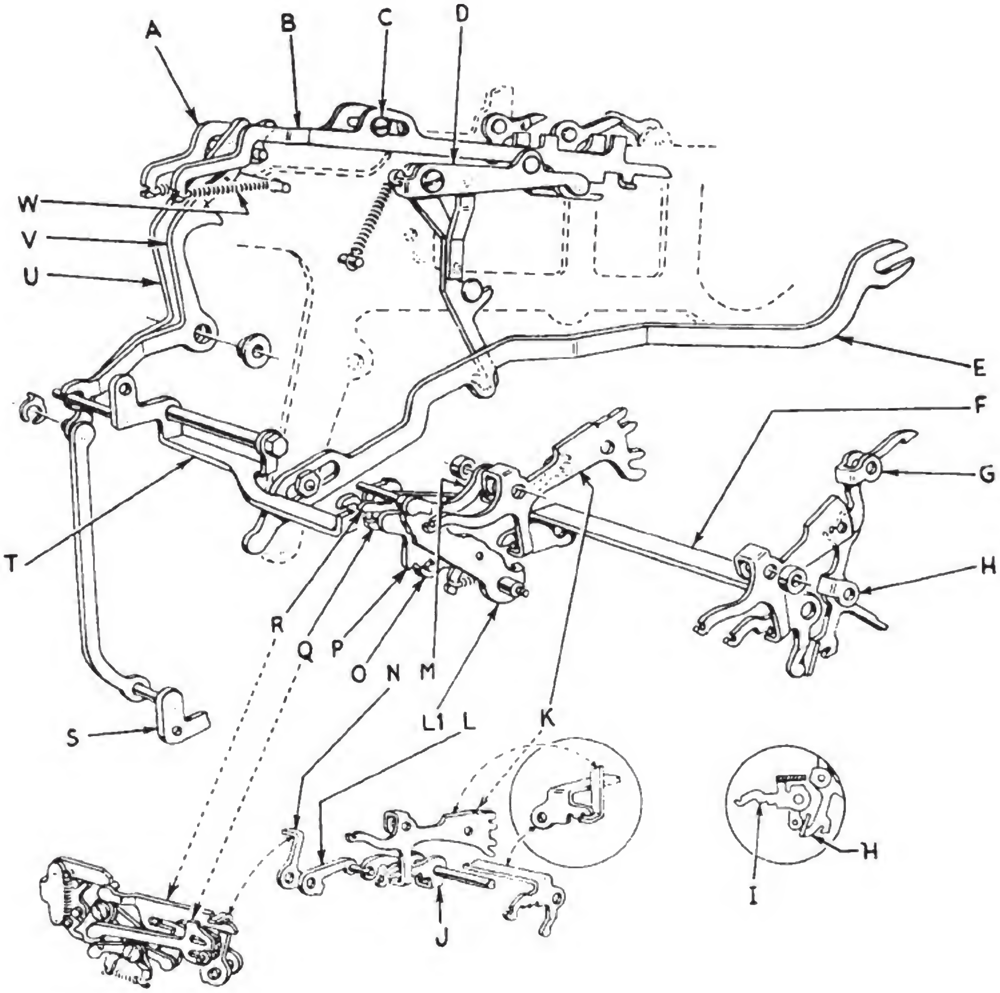
2. Lip A must block forward movement of slide B in order to block the result keys. Lip A should have normal binding clearance with the forward edge of the step in slide B when arm Q is raised or lowered manually. To adjust, bend lip A.

3. Bend finger D TO or FROM roll E, as necessary, to safeguard against premature depression of the total keys. When the machine is normal, there should be a clearance of approximately .005" between lip I and the lower edge of slide F.

DRIVE CLUTCH TRIP MECHANISM

Study the drive clutch trip mechanism of the Series P400 adding machine in figure 6-35.

When a motor bar or a control key is depressed, the action lowers link AF and arm AI. Arm AI then moves latch AH down and out of engagement with the square stud in arm AE, thus permitting arm AE to be pulled down in position for turning shaft assembly AJ. When shaft AJ turns it raises arm AK to disengage hook B from the stud in arm A, thereby allowing the clutch dog to engage the drive gear and the switch points to close the circuit and run the motor and machine.



A. Minus balance total slide (register B)
B. Minus balance total slide (register A)
C. Screw which holds slide B
D. Bellcrank which actuates link E
E. Link to index subtract mechanism
F. Automatic one carry bail
G. Upper carry pawl
H. Lower carry pawl
I. Carry rack latch used in machines which have less than 13 columns
J. Carry rack latch in column one
K. Carry rack in column one
L. Bail which actuates latch J
L1. Brace
M. Arm which lowers links Q and R
N. Lip on bail L
O. Detent arm
P. Detent which holds links Q and R in position
Q. Link which rocks bail L
R. Link which rocks bail L
S. Bail which actuates slide A
T. Bail which actuates slide B
U. Arm which restores slide A to normal position
V. Arm which restores slide B to normal position
W. Spring which pulls slide B into the minus balance position

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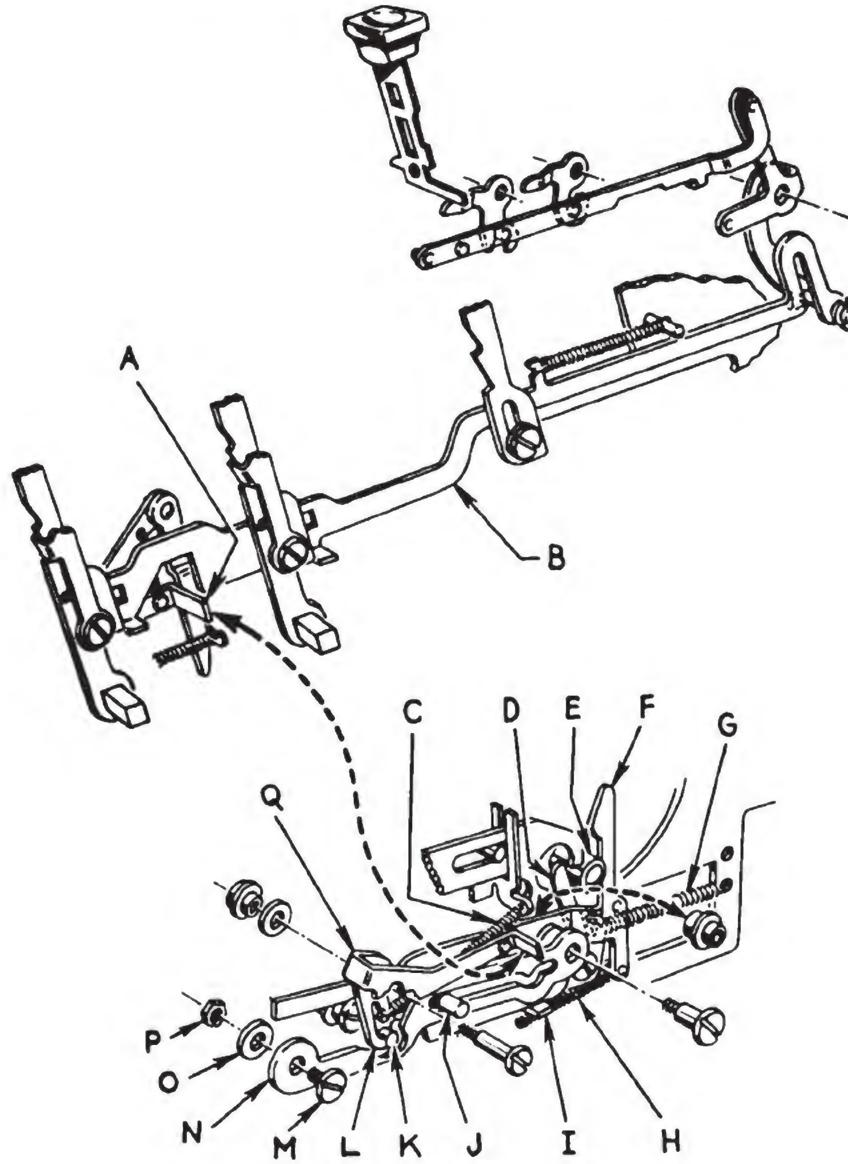
Figure 6-33.—Minus balance mechanism.



A. Lip which blocks forward movement of interlock B
B. Interlock which prevents simultaneous depression of total keys and motor bars
C. Spring which rocks timing arm (Q)
D. Latch which holds timing slide to the rear
E. Roll on secondary mechanism
F. Timing slide to control timing arm
G. Spring on latch D
H. Spring which restores slide F
I. Lip on latch D
J. Stud on slide F
K. Stud on slide F which holds timing arm normal
L. Tail on timing arm
M. Screw which holds washer O and nut P
N. Timing arm which controls timing slide F
O. Washer used for added weight to timing slide F
P. Nut which holds washer on screw M
Q. Timing arm which controls interlock B

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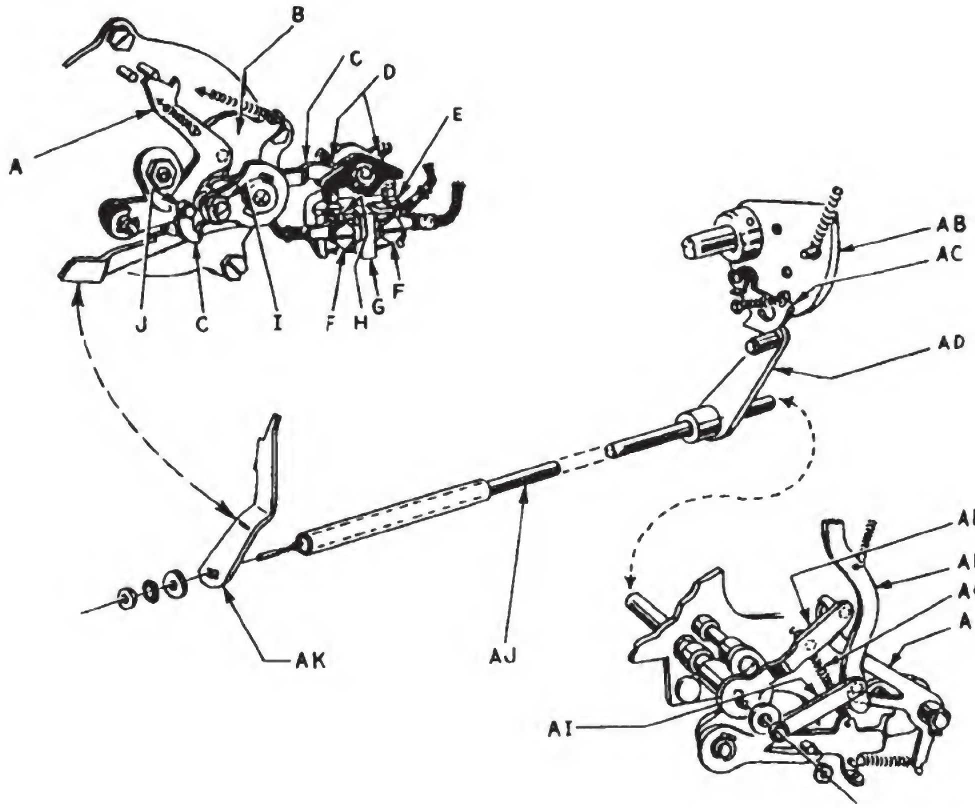
Figure 6-34.—Total timing mechanism.



A. Arm which holds hook B in normal position
B. Hook which controls release of clutch dog.
C. Upper switch point assembly
D. Springs which connect upper switch point retainer to the switch point arm
E. Lower front switch point
F. Screw which retains lower front and rear switch points
G. Lower switch points retainer
H. Lower switch point (rear)
I. Eccentric bushing
J. Rollon arm A
AB. Timing cam on secondary mechanism
AC. Pawl which delays tripping of drive clutch
AD. Limit arm on shaft AJ
AE. Arm which holds trip shaft AJ in normal position
AF. Link on intermediate motor bar assembly
AG. Spring which pulls arm AE
AH. Latch which retains arm AE in normal position
AI. Arm which disengages latch AH from arm AE
AJ. Clutch trip shaft
AK. Clutch trip arm

91.173X

Figure 6-35.—Drive clutch trip mechanism.

During a return stroke, the roll on arm AD rides over pawl AC to provide sufficient time for the completion of a relay carry.

For additional information on the drive clutch trip mechanism, and all other parts and mechanisms of the Series P400 adding machine, refer to the manufacturer's technical manual. Always keep this manual available when you are making adjustments on the machine.

CHAPTER 7

WATCH REPAIR

This chapter tells how to make a casualty analysis of a watch and explains technical terms and nomenclature. (See Appendix I for a glossary of watch and clock terms.) It also gives a detailed discussion of the operating characteristics of a watch escapement, and explains the procedure for replacing roller jewels, pallet arbors, guard pins, moving pallet stones, and straightening a pallet arbor. It explains the operation of the MAIN TRAIN and tells how to determine the number of teeth or leaves in a lost wheel or pinion. Full coverage is given to the procedure for repivoting instrument pinion staffs and arbors, and emphasis is placed on the replacement of such watch parts as cannon pinions and mainsprings. Chapter 10 of this training course gives the procedure for adjusting watches and clocks.

Although this chapter gives many details and procedures pertaining to watch repair, bear in mind that watch repair is highly technical and delicate work which can be mastered only through experience, which you will receive under competent supervision in Navy instrument shops.

CASUALTY ANALYSIS

When a watch is brought to the instrument shop for repair, your job as an Instrumentman on duty in the shop is to locate the trouble and eliminate it. In doing this, you make what is known as a CASUALTY ANALYSIS—you inspect and disassemble the watch as necessary until you locate the difficulty. Enter your findings on the casualty analysis report.

The accompanying TROUBLESHOOTING CHART will help you locate trouble in a watch mechanism. It covers most of the difficulties you will encounter in watch repair, and you should study it and use it as a reference.

REPLACEMENT OF WATCH PARTS

This section gives the procedures for replacing defective or broken watch parts—balance staffs, cannon pinions, and mainsprings.

REPLACING A BALANCE STAFF

As you learned in previous study, the balance staff is the shaft on which the balance wheel is mounted. The rotating axis around which the balance wheel oscillates is formed by a line running through the pivots at each end of the staffs. The pivots fit in jewels capped by endstones. Study carefully figure 7-1, which shows a typical balance staff and lists the nomenclature. Then take a look at two defective balance staffs illustrated in figure 7-2. Note the defects in each one, particularly the damage caused to one pivot by a cracked jewel.

When you replace a defective or broken balance staff, turn the old staff off with a graver. DO NOT ATTEMPT TO KNOCK IT OUT.

There are three types of riveted balance staffs and a friction-fitted type. See figure 7-3, which gives some common forms of riveted balance staffs.

You can remove a standard rivet-type balance staff by turning off the hub under the balance arm, or by turning off the rivet (on top of the balance arm). The turning-off-the-hub method has two advantages and is generally preferred: (1) the balance shoulder of the staff will not be forced through the hole of the balance wheel; and (2) because the staking process hardened the metal in the rivet, the hub is easier to turn than the riveted shoulder. However, if this type of staff cannot be replaced from stock and must be made on a lathe, remove the balance staff by turning off the rivet.

TROUBLESHOOTING CHART

Fault	Cause(s)	Remedy
Crown unscrews.	Stem rusty. Threaded portion of stem is burred.	Remove the rust. Remove burs with a fine file or with an oilstone.
Stem pulls out.	Loose stem screw. Damaged stem.	Tighten the detent screw. Replace the detent.
Stem will not stay in winding position.	Shoulder on detent is worn. Square on detent is too long. Clutch lever spring is broken.	Replace the stem. Replace the clutch lever spring.
Watch stops; has trouble in winding mechanism.	A broken clutch lever spring allows the clutch pinion to engage the setting wheel. Worn shoulder allows the watch stem to shift into the setting position.	Replace the clutch lever spring. Replace the watch stem.
The watch cannot be fully wound.	The mainspring is broken. The barrel cover is disengaged from the barrel. The click spring is broken. Dial is too loose, causing the second hand to become fouled up.	Replace the mainspring. Reassemble the barrel assembly. Replace the broken click spring. Tighten the dial screws.
Watch stops; has faulty dial.	The dial is not centered properly, causing the hour wheel and second wheel and second hand pipe to bind on it.	Position the dial by changing the location of dial feet. Avoid breakage.
Watch stops; hands not properly positioned.	Hands touch the dial or the crystal. The hands catch. The hour hand pipe binds on the hole in the dial. The minute hand hub binds on the hour wheel hub.	Adjust hands as necessary to have them move parallel with the dial. Adjust, as above. Center the dial. Set the hour hand and the minute hand squarely on the hour wheel and the cannon pinion, respectively.
Hands fail to indicate correct time.	The hands are loose on the hour wheel or the cannon pinion. Hands are improperly set. Hour and minute wheels are enmeshed. Watch runs; hands fail to move.	Tighten the hands in the 12 o'clock position with the watch set for this position. Place the dial washers on the hour wheel between the hour wheel and the dial. Tighten the cannon pinion.

TROUBLESHOOTING CHART—Continued.

Fault	Cause(s)	Remedy
	THE ESCAPEMENT	
The roller jewel is out of action with the fork slot.	Pallet jewels are not set properly.	Reset the pallet jewels.
	The guard pin is bent.	Straighten and adjust pin.
	Guard pin is broken.	Replace the guard pin.
	Guard pin is too short.	Replace the guard pin.
	The fork is bent.	Straighten the fork.
	There is too much sideshake or endshake in the pallet or balance.	Adjust bridges or replace the staffs, bushings, or jewels.
	The banking pins are not adjusted properly.	Adjust the banking pins.
	The roller table is not of the correct size.	Replace the roller table.
Watch stops—the escapement assembly is faulty.	The escapement is dirty, or is not oiled properly.	Disassemble the escapement; then clean and oil.
	Pivots are bent or broken.	Straighten or replace pivots.
	The roller jewel is out of action with the fork slot.	Remedy was explained above.
	There were burrs on the escape wheel.	Remove the burrs with an oilstone.
	Some escape wheel teeth are bent or broken.	Replace the escape wheel.
	Some jewels are broken.	Replace the jewels.
	Jewels are improperly set or are loose in their settings.	Reset the jewels.
	The roller jewel is loose.	Reset the roller jewel.
	There is excessive oil on the upper pallet or the staff pivot.	Disassemble, clean, and lubricate.
	BALANCE ASSEMBLY	
Watch stops—balance assembly is faulty.	The balance staff is bent or broken.	Replace the balance staff.
	The balance jewels are loose or broken.	Replace the balance jewels.
	The balance or balance jewels is dirty.	Disassemble, clean, and lubricate.
	The roller jewel is loose or broken.	Tighten or replace the roller jewel.
	The roller table is loose.	Tighten or replace the roller table.
	The hairspring is bent.	Straighten or replace the hairspring.
	The hairspring is broken.	Replace the hairspring.
	There is oil on the hairspring.	Clean the balance unit.
	Hairspring is magnetized.	Demagnetize the watch.
	Balance screws are loose.	Tighten the balance screws.
	The balance is not true.	True the balance wheel.
	The balance wheel is loose on the staff.	Restake the balance wheel on the staff.
	There is a loose balance bridge.	Tighten the balance cock screw.

TROUBLESHOOTING CHART—Continued.

Fault	Cause(s)	Remedy
	BALANCE ASSEMBLY—Continued.	
Watch stops—balance assembly is faulty—Continued.	There is excessive endshake or sideshake.	Make necessary adjustments.
	The balance rims strikes the center wheel, hairspring stud, regulator pins, or some other point.	Check the balance jewels for correct position and depth, center the wheel for trueness, check hairspring study for correct position, and the balance cock for burrs on the underside.
	The balance rim strikes the pallet bridge.	Check the lower balance jewels for proper depth, the underside of the pallet bridge for burrs, and the pallet bridge for correct position and tightness.
	The small roller table strikes the lower hole jewel setting shoulder.	Turn the shoulder back or replace the jewel.
	The edge of the safety (small) roller is rusty or gummy.	Buff and polish the edge of the roller with a hand buff.
The watch runs too fast—balance assembly is faulty.	There is oil on the hairspring.	Clean the hairspring.
	The watch is magnetized.	Demagnetize the watch.
	Other coils of hairspring are between the regulator pins with the outside coil.	Release the spring and make corrections.
	Hairspring is twisted or bent.	Straighten or replace hairspring.
	Balance wheel is not properly poised.	Poise the balance wheel.
	The regulator pins bind the hairspring.	Spread the regulator pins.
	Hairspring not correct one.	Replace the hairspring.
	Balance screws are missing.	Replace the balance screws.
	Hairspring strikes the center wheel or some other point.	Adjust the hairspring as required to prevent its touching other parts (adjacent).
	The hairspring and the balance wheel are dirty or gummed with oil.	Clean the balance unit.
	The regulator pins are spread apart too far.	Close the regulator pins.
	The rim of the balance wheel strikes other parts of the watch.	Check the position of the balance as related to the balance cock, pallet bridge, center wheel, regulator pins, or hairspring stud. (Make test with watch in different positions.)
		Replace balance staff.
		Replace balance jewel and balance staff, if bent or cut.

TROUBLESHOOTING CHART—Continued.

Fault	Cause(s)	Remedy
TRAIN MECHANISM		
Watch stops—the train mechanism is faulty.	The teeth or pinions of the train wheels are dirty.	Disassemble the train and clean it.
	Movement was improperly oiled, or the oil is gummy.	Disassemble the train and clean it.
	Some teeth or wheels are bent.	Straighten the teeth or wheels; if necessary, replace the wheels.
	There are burrs on the teeth of the wheels.	Remove the burrs with an oilstone.
	The bushings are worn.	Replace the bushings.
	There is improper depthing of the wheels and pinions.	Replace them, or rebush the wheels.
	There is insufficient endshake or sideshake for the wheels.	Straighten the pivot or replace the wheels.
	There is a cracked plate jewel.	Replace the jewel.
	The jewels are improperly set.	Reset the jewels.
	There is a loose jewel.	Reset the jewel.
	The bridge plate is loose.	Tighten the screw in plate.

Turning off the Hub

Refer to the illustrations as you study the procedure for turning off the hub of a standard-type balance staff.

Insert the balance staff in a chuck and secure the chuck in a lathe, in the manner shown in figure 7-4. Then hold a sharp, pointed graver at the angle illustrated and shave off the roller seat of the hub. Apply even pressure on the graver.

As the shavings begin to fall from the hub, swing the graver slightly to the right. In this position, the point of the graver cuts deeper than the sides into the roller seat, forming a V groove (fig. 7-5).

When you get the metal of the hub turned almost to the balance arm, the point of the graver breaks through (fig. 7-6), leaving a loose ring of metal (outer portion of the turned-off hub). Use care to prevent damage to the balance arm.

You can usually ease the balance wheel off the staff with your fingers; but if it does not come off readily, use a staking tool, as illustrated in figure 7-7.

Turning off the Rivet

Exercise considerable care when you turn off the rivet on the arm of a balance wheel. Use a graver in the same manner as for turning off the hub. Do NOT scratch or damage the balance arm with the graver. The procedure for turning off the rivet is illustrated in figure 7-8.

Staking a Balance Wheel

The process for securing a balance wheel to a balance staff is known as STAKING, as you learned in Instrumentman 3 & 2, NavPers 10193-B, when you learned how to stake a balance wheel to a standard-type balance staff. The next few paragraphs discuss ONLY the procedure for staking balance wheels on TOP-GROOVE, SIDE-GROOVE, and FRICTION-FITTED balance staffs.

Figure 7-9 shows the procedure for staking a balance wheel to a top-groove balance staff. Use a flat seating punch with a wide mouth to bring the balance arm firmly into contact with the balance seat. Note that the punch does not touch the seating shoulder. Then use another flat seating punch with a small mouth to hammer the riveting shoulder flat. Use gentle taps with a small hammer. The completed staking job is shown in part C of figure 7-9.

Figure 7-10 shows how to put a balance wheel on a friction-fitted staff. Note in part A that the staking punch has a round nose which fits on top of the hub seat. With a punch of this type, you can bring the hub seat into positive seating position in the hub. Part B of figure 7-10 illustrates the procedure for staking a balance wheel on another type of friction-fitted staff. You need a flat-face staking punch of the size illustrated for pressing the staff into its seated position, with the hub seat on the staff in positive contact with the balance wheel hub.

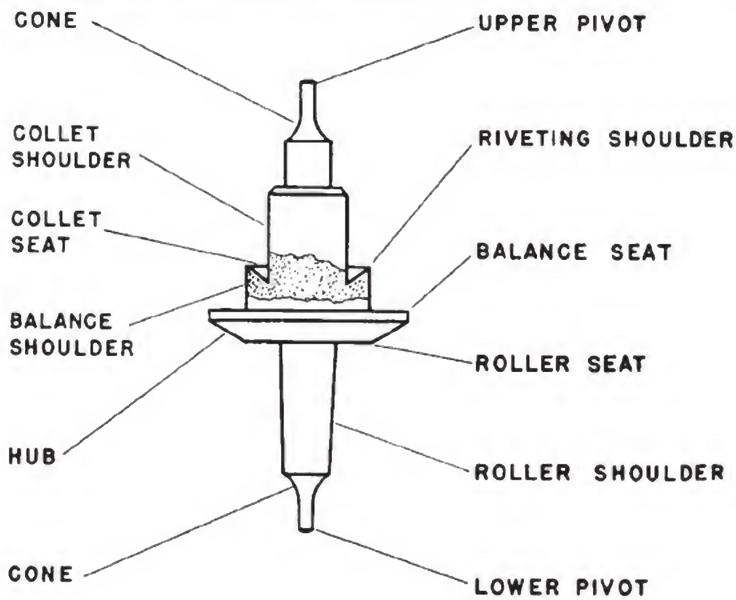


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Figure 7-1.—Nomenclature of a typical balance staff.

REPLACING A CANNON PINION

The dial train consists of the cannon pinion, minute wheel, and the hour wheel. The cannon pinion is a hollow steel pinion mounted on the center wheel arbor. A stud secured in the pillar plate holds the minute wheel meshed with the cannon pinion. Attached to the minute wheel is a small pinion meshed with the hour wheel.

The center arbor revolves once per hour. A hand secured to the cannon pinion on the center arbor travels around the dial once each hour. This hand denotes minutes. The minute wheel is in mesh with the cannon pinion. The hour wheel has a pipe which enables it to sit over the cannon pinion, and it meshes with the minute wheel pinion. This completes the dial train. The ratio between the cannon pinion and the hour wheel is 12 to 1; therefore, the hand fastened to the hour wheel denotes hours. If the cannon pinion is too tight, it would be difficult to set the watch hands; if it is too loose, the stem turns too freely. When damaged, a cannon pinion must be replaced, as explained next.

Note the position of the cannon pinion in figure 7-11. It is located beneath the hour wheel.

Figure 7-12 shows how to remove the cannon pinion with one type of remover. Lift straight up on the remover to prevent bending or breaking. You can also remove a cannon pinion with a pair of good tweezers or a pin vise.

Before you install a new cannon pinion, thoroughly clean all parts of the dial train, and other parts of the watch. The arbor on which the cannon pinion fits must be free of blemishes and show little wear. Any part which shows wear which may interfere with efficient operation of the mechanism MUST BE REPLACED.

To prevent bending or binding, use much care in fitting a new cannon pinion to the arbor and center wheel. Select proper tweezers for doing the work. A cannon pinion should fit tight, with equal friction all around the center arbor. If it is loose when in position on the arbor, tighten it in the manner illustrated in figure 7-13. Seat it on a tapered, round broach (brass wire) and then move it slightly toward the tapered end of the wire. With a pair of cutting pliers (with rounded-off cutting jaws), tighten the cannon pinion at its slot. The tension of the pinion on its arbor should be sufficient to carry the dial train and the hour wheel, but not tight enough to prevent setting of the hands.

Some watch repairmen use steel wire instead of brass wire. Pliers with a setscrew for setting the amount the jaws may be closed are also used. If you use such pliers, close the jaws on the cannon pinion at the spot indicated in figure 7-13 and turn the setscrew in to get the correct measurement between the jaws in this position. Then remove the pliers and unscrew the setscrew just enough to enable you to put the amount of indentation desired on the cannon pinion at the spot indicated. If this does not make the pinion fit tight enough, unscrew the setscrew a little more and repeat the process.

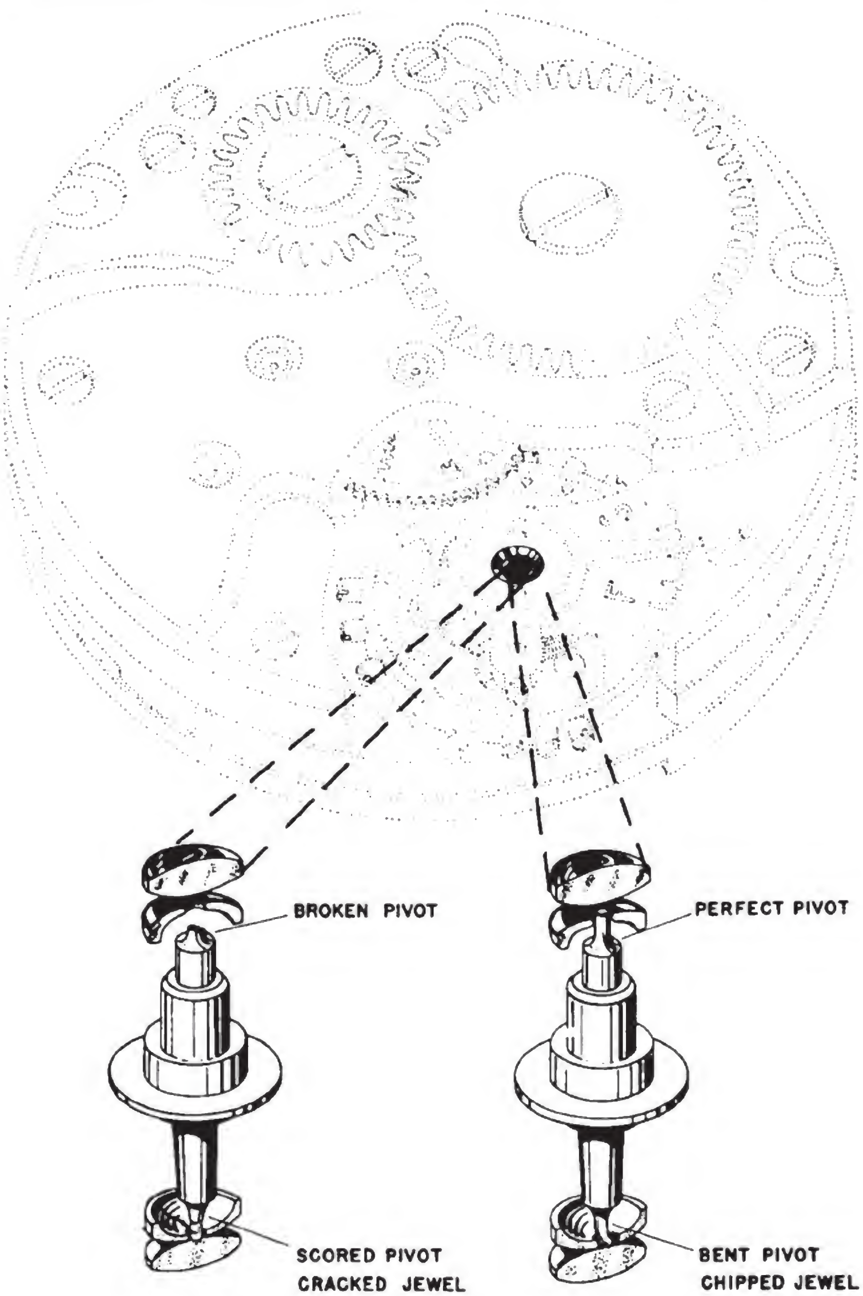

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Figure 7-2.—Defects in balance staffs.

REPLACING A MAINSPRING

A watch, like an engine or any other mechanical contrivance, must depend on a steady source of motive power. The power assembly in a watch consists of the mainspring, mainspring barrel, arbor, and cap. The mainspring provides essential power to run a watch. It is coiled around the arbor and is contained in the barrel, cylindrical in shape, with a gear on its outer edge, which meshes with the center wheel pinion. This gear is the first wheel of the watch train. The arbor is a cylindrical shaft with a hook in the center for attaching the mainspring. The cap is a flat disk which snaps into a recess in the barrel. The mainspring barrel has a hook on the inside edge to which the mainspring is attached.

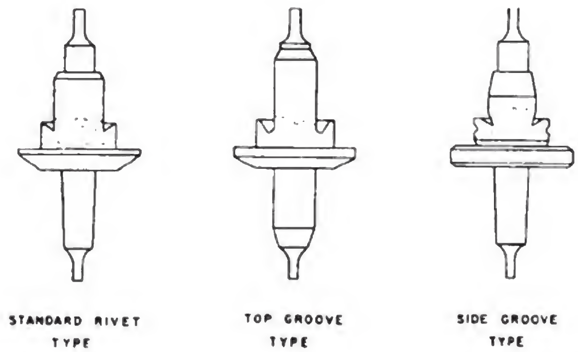

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Figure 7-3.—Common forms of riveted balance staffs.

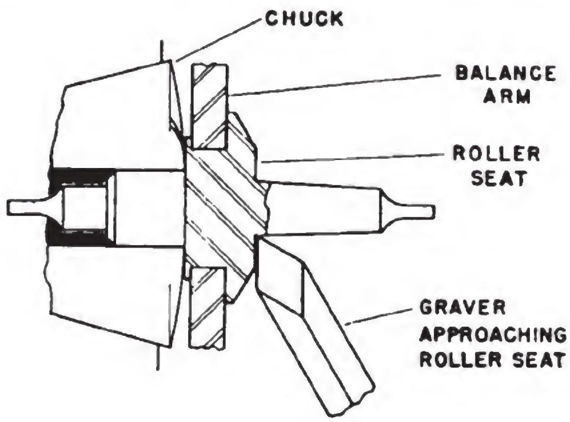

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Figure 7-4.—Turning off the hub of a standard balance staff.

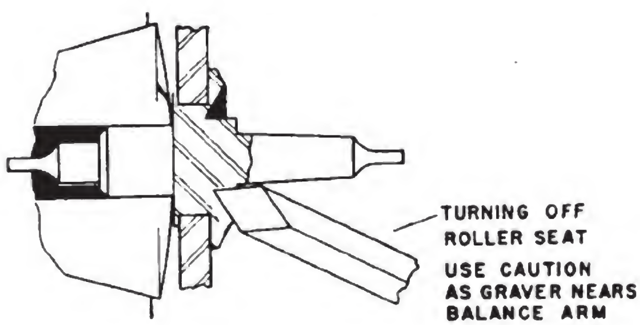

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Figure 7-5.—Turning off the roller seat of a balance staff.

Study a watch power assembly (mainspring barrel assembly) in figure 7-14. Note the gear around the top of the barrel in the front view, and then note in the side view how this gear

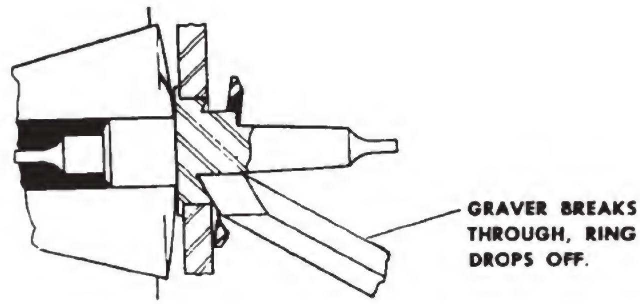

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Figure 7-6.—Graver breaking through the hub of a balance staff.

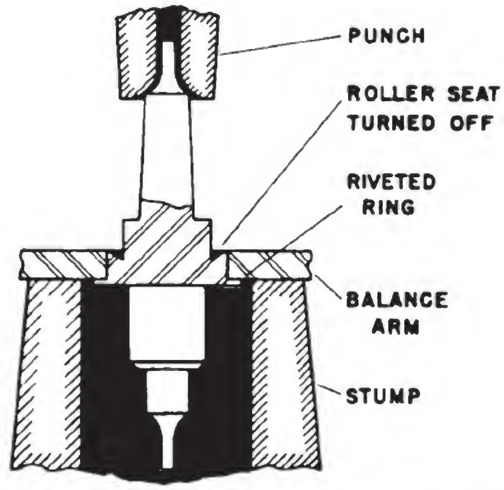

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Figure 7-7.—Removing the balance wheel from the balance staff.

meshes with the center wheel pinion. Study the nomenclature shown in the side view of the assembly. Observe also the position of the ratchet wheel, which turns the barrel arbor when the watch is wound.

A mainspring is made of a long, thin strip of steel, hardened as necessary to give the desired resiliency. Mainsprings vary in size, but each has a hole in the inner end to secure it on the mainspring barrel arbor and a hook on the outer end for attaching it to the mainspring barrel.

Removing Mainspring from Barrel

To remove a mainspring from a barrel, hold the barrel between the thumb and the index finger (with barrel supported on an anvil) and pry off the cap with a screwdriver inserted in the cap slot. Remove the barrel arbor; then grasp the inside

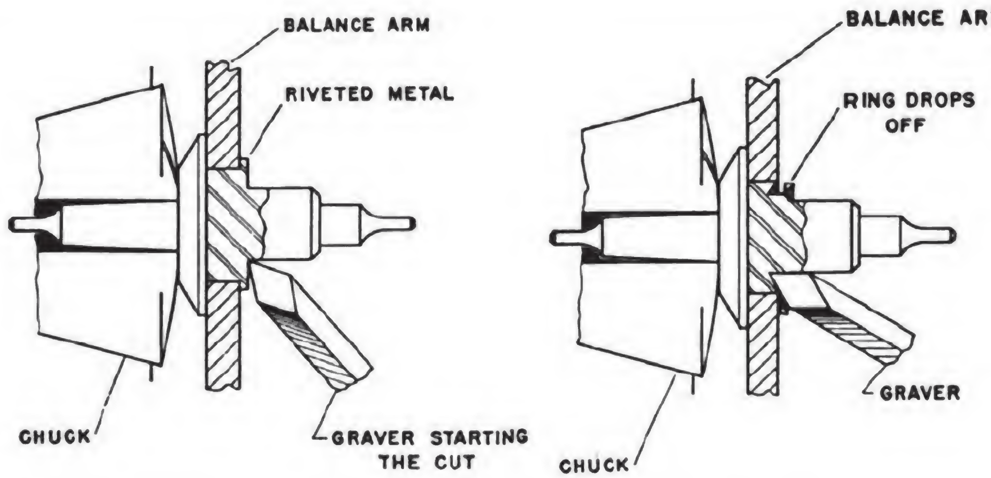

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Figure 7-8.—Turning off the rivet of a balance staff.

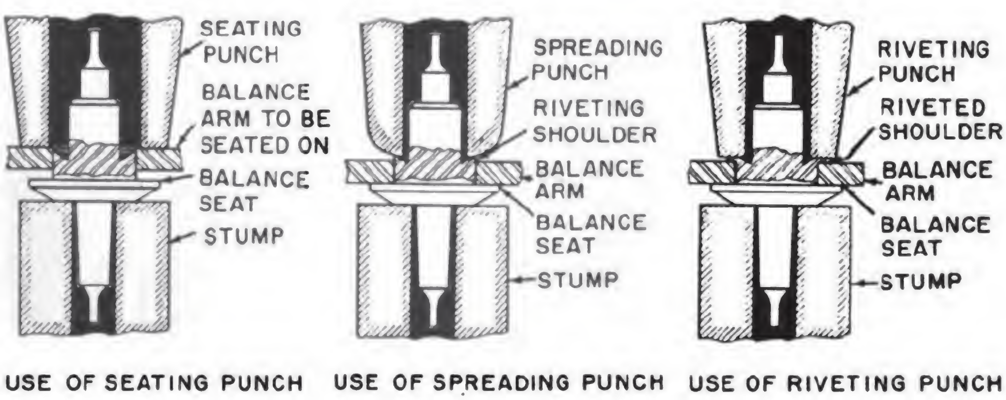

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Figure 7-9.—Staking a top-groove balance staff.

coil of the mainspring with tweezers and SLOWLY pull it out of the barrel, allowing it to uncoil gradually.

Thickness of Mainspring

The thickness of a mainspring determines its strength. A spring which is TOO thick causes the motion of a watch to increase beyond safe limits, resulting in the banking of the roller jewel against the pallet fork. Accurate regulation of a watch under such conditions is impossible. On the other hand, if a spring is TOO thin, it does not have sufficient power to run the watch. When you first wind the watch, the balance motion may be satisfactory; but after the weak spring runs a few hours, it does not have enough tension to maintain good running motion of the balance wheel.

If you need a mainspring for a watch of standard make, use a genuine factory-made spring specified by the manufacturer for the specific model. If you do not know the manufacturer of the watch, use a small micrometer or a Dennison mainspring gage to measure BOTH thickness and width of the mainspring required. See figure 7-15.

In determining the proper thickness of a mainspring for a given barrel, take into consideration the following:

1. The INSIDE barrel diameter should be three times as great as a given arbor diameter. The area covered by the spring should be one half the net difference in area between the barrel and the arbor.

2. For a barrel arbor of given size, the mainspring thickness should vary 1/26 to 1/34 of the arbor diameter, depending upon the quality

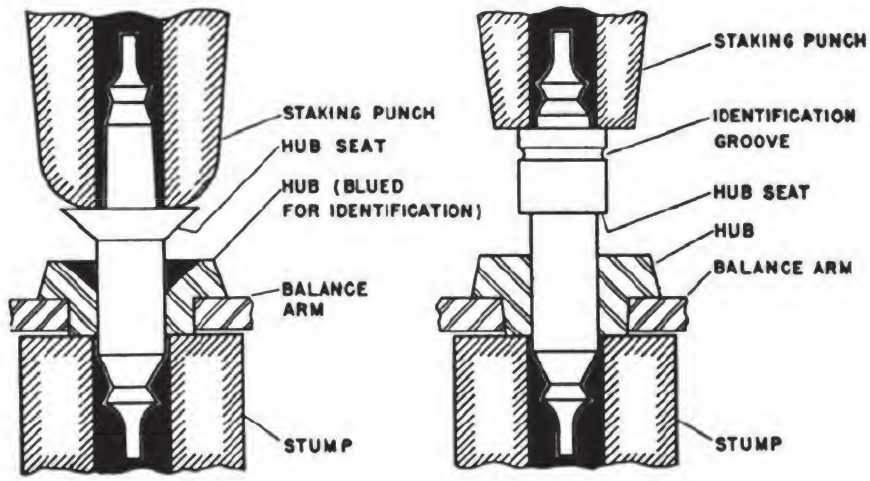

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Figure 7-10.—Staking a friction-fitted balance staff.

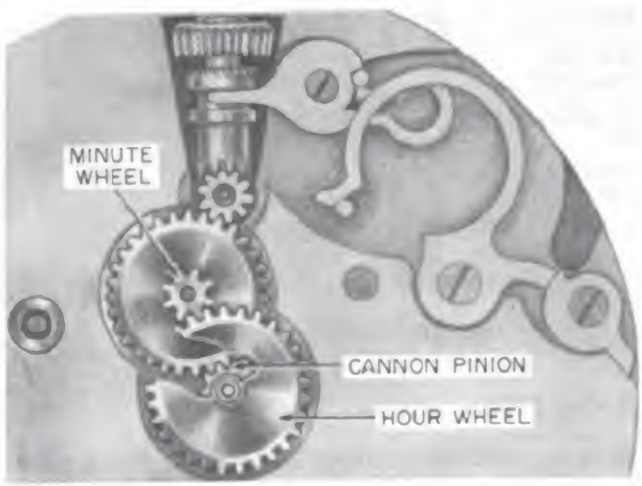

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Figure 7-11.—Position of cannon pinion in the dial train.

of the movement. The following guide shows that the better the quality of a watch movement the weaker the spring required.

GUIDE TO MAINSPRING THICKNESS

Pocket Watches

7-15 jewels—mainspring thickness, 1/26 arbor diameter
15-17 jewels—mainspring thickness, 1/28 arbor diameter
17-19 jewels—mainspring thickness, 1/30 arbor diameter

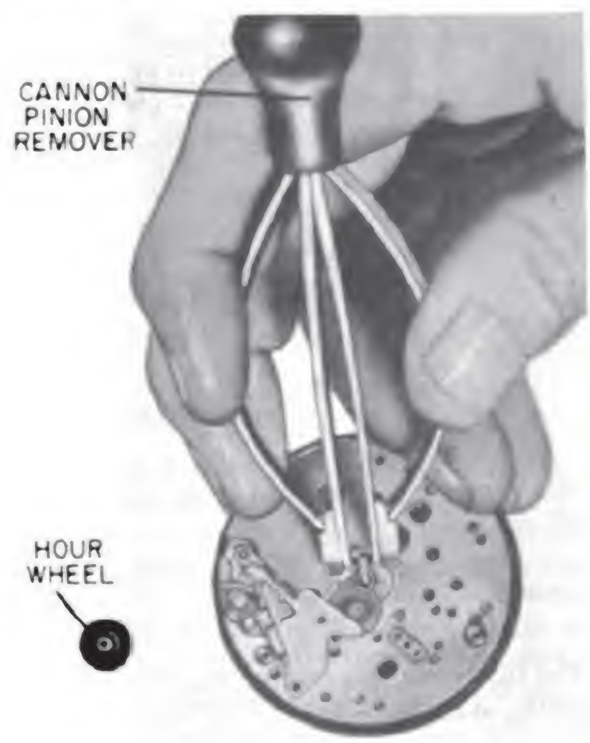

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Figure 7-12.—Removing a cannon pinion.

19-21 jewels—mainspring thickness, 1/32 arbor diameter
21-23 jewels—mainspring thickness, 1/34 arbor diameter

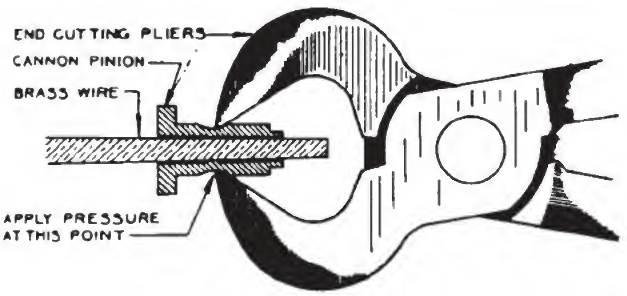

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Figure 7-13.—Tightening a cannon pinion.

Wrist Watches

7-15 jewels—mainspring thickness, 1/28 arbor diameter
15-17 jewels—mainspring thickness, 1/30 arbor diameter
17-19 jewels—mainspring thickness, 1/34 arbor diameter

NOTE: Use these figures as a guide ONLY when data from the manufacturer is unavailable. Irregularities in banking, pivots, and depthing, void ALL these rules.

3. The number of barrel revolutions possible with a given spring is equal to the difference in the number of coils between the WOUND UP and the RUN DOWN positions of the spring.

4. If a spring occupies 1/2 the net difference in area between the barrel and arbor, the last coil when wound up and the first coil when run down both lie on a common circle called the UP AND DOWN CIRCLE (fig. 7-16). When lines AC and BC in this illustration are drawn with 45° angles with the diameter of the mainspring barrel, their point of intersection (C) gives the position of the UP AND DOWN CIRCLE. When the spring is wound in the barrel, the last coil should meet this circle. Line CO is the diameter of the UP AND DOWN CIRCLE.

5. The diameter of the UP AND DOWN CIRCLE is approximately equal to 3/4 the inside barrel diameter when the barrel is ONLY THREE TIMES the arbor diameter.

Length of Mainspring

If a mainspring is TOO LONG, it does not leave enough space in the barrel for unwinding. This means that the watch will not run its maximum number of hours. Take a look at an OVERSIZED mainspring in part A of figure 7-17, and then compare it with the CORRECT-SIZE mainspring in figure 7-14.

A mainspring that is too short does not have a sufficient number of coils for unwinding, which means that the watch will not run its maximum number of hours. Compare the SHORT mainspring in part B of figure 7-17 with the one in figure 7-14.

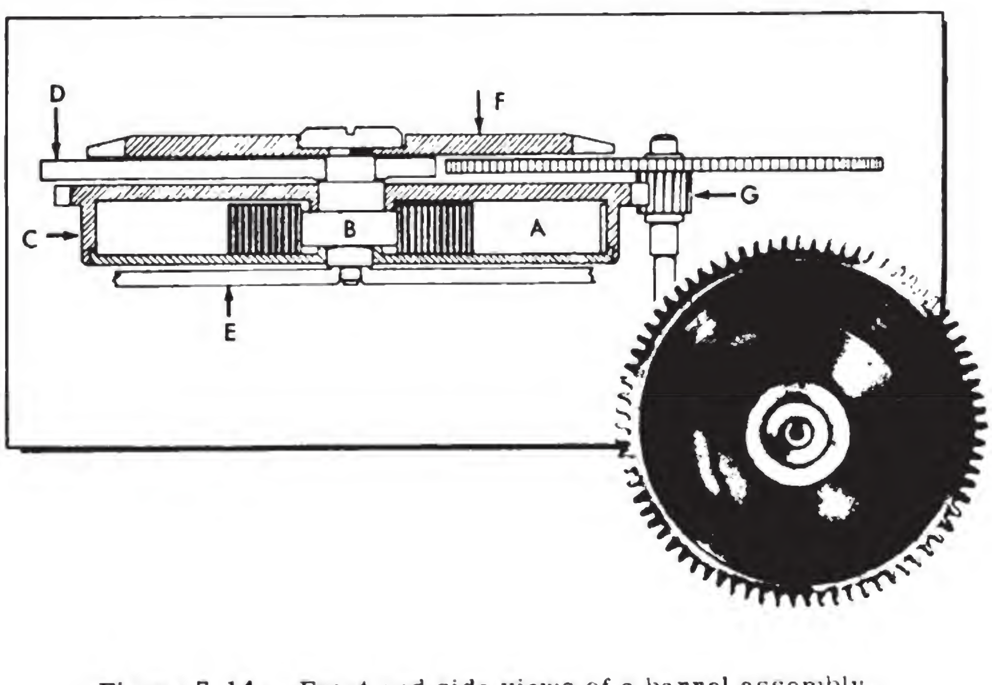

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Figure 7-14.—Front and side views of a barrel assembly.

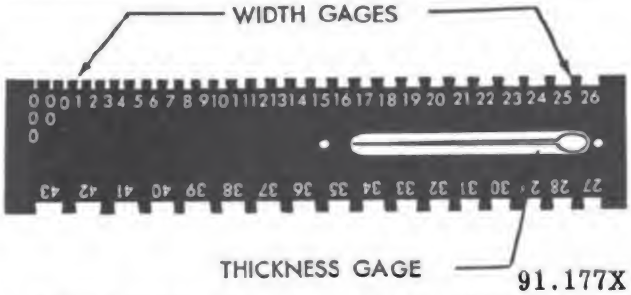

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Figure 7-15.—Dennison mainspring gage.

If you must determine the correct length of a mainspring for a given watch, use W. Dodgion's equation, as follows:

$$\frac{(B+A) \times (B-A)}{64.6 \times T} = \text{length of mainspring in inches}$$

A = arbor diameter in millimeters
B = inside diameter of barrel in millimeters
T = thickness of mainspring in millimeters

Inserting Mainspring in Barrel

Use a mainspring winder for inserting a mainspring into its barrel. If you attempt to feed it into the barrel with your fingers, you may cause damage that will render it unfit for reliable service. Winders are made in different sizes to accommodate various sizes of mainspring barrels. Study parts A and B of figure 7-18, which show the procedure for winding a mainspring into a mainspring winder and for transferring the mainspring to the barrel, respectively.

The procedure for using a mainspring winder follows:

1. Select a proper-size mainspring winder.
2. Check the position of the hook on the arbor to determine the direction for winding the spring. Wind the spring in a reverse direction to the position it will have in its barrel.
3. Attach the inner coil of the mainspring to the arbor of the winder.
4. Wind the spring into the barrel of the winder.
5. Place the winder over the barrel, with the end of the spring at the hooking end of the barrel. (If it is the tongue-type, the tongue must be bent away from the spring.)
6. Insert mainspring into barrel (part B, fig. 7-18).
7. Lubricate the mainspring and arbor with HEAVY oil. (Pressure between coils of a fully wound spring would force light oil from the spring and cause a binding which would result in uneven power and inaccurate regulation.)
8. Hold the barrel on tissue paper in the left hand and place the cover (held with tissue paper in the right hand) on the barrel, lined up with a scratch mark on the side of the barrel. Then overlap the cover with tissue paper in both right and left hands (to keep finger prints off)

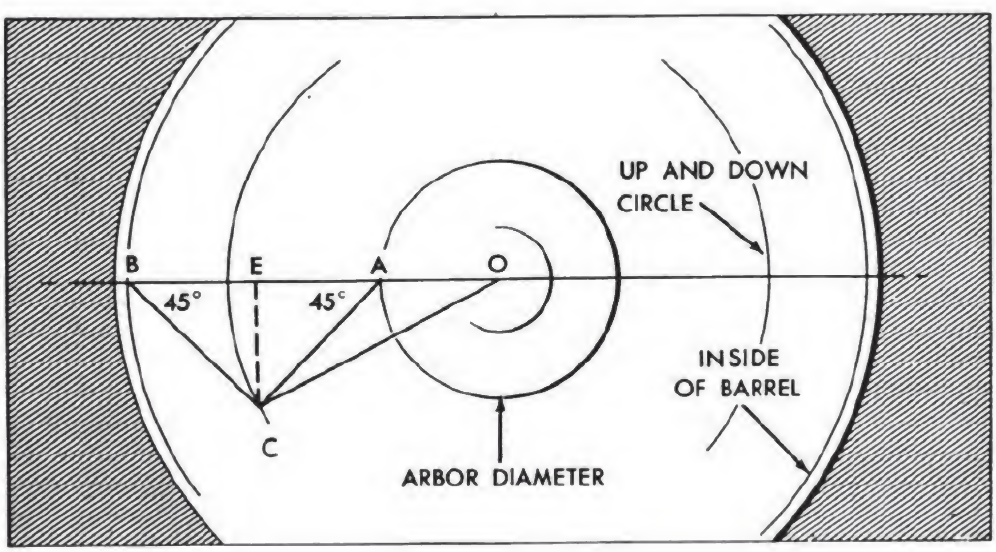

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Figure 7-16.—UP AND DOWN CIRCLE.

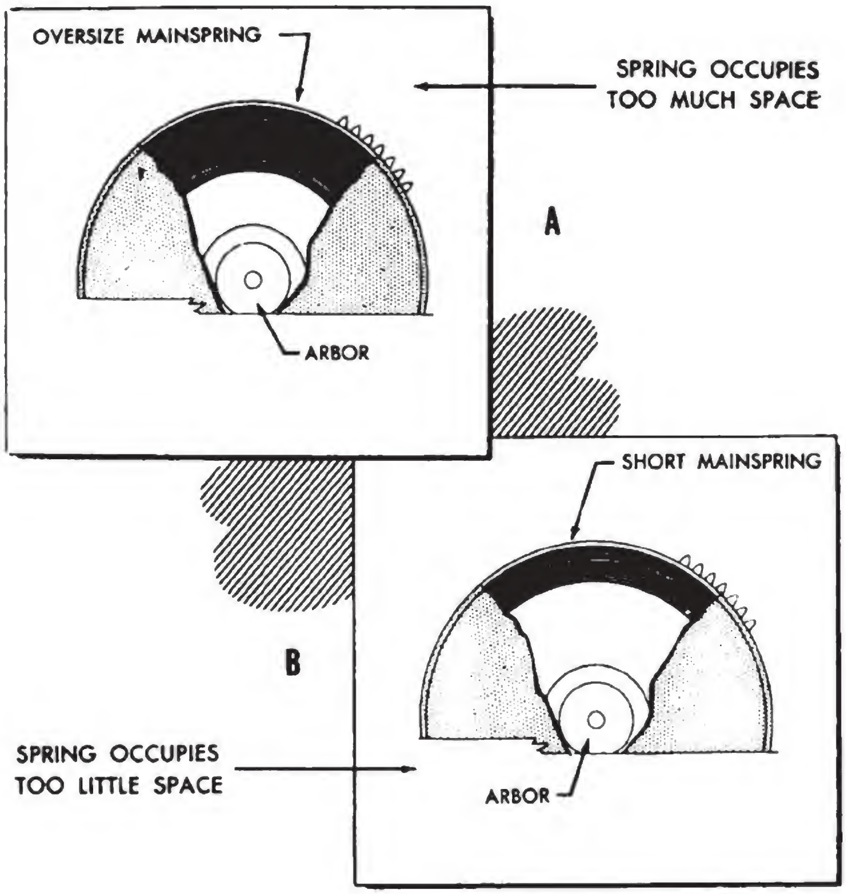

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Figure 7-17.—Over-and under-sized mainsprings.

and snap the cover on the barrel. If necessary apply force to cover with a brush handle to snap it into place.

9. Remove dirt and fingerprints from the barrel.

MAIN WATCH TRAIN

The main train of a watch is a set of wheels through which the power of the mainspring is transmitted to the escapement. The cogwheel on the mainspring barrel constitutes the FIRST wheel of the train. Because of its position in a watch movement, the second wheel is called the CENTER wheel. The THIRD, FOURTH, and ESCAPE wheels complete the main train. The center, third, and fourth wheels are made of brass, mounted on steel pinions and arbors. The long center wheel arbor projects through the pillar plate and above the dial, to receive the cannon pinion and the hour wheel.

The main train (sometimes called the time train) changes the SLOW motion of the mainspring barrel into FAST motion, causing the cannon pinion carrying the minute hand to make one turn every time the escape wheel makes the required number of beats (18,000 per hour in a pocket watch). Another train, called the dial train, governs the distance the hour hand travels to one turn of the minute hand. In other words, the dial train converts FAST motion to SLOW motion.

Turns of a Pinion

To determine the number of turns a pinion makes, divide the number of teeth in the wheel by the number of leaves in the pinion. For example, if a wheel with 72 teeth meshes with a pinion with 12 leaves, the pinion makes 6 turns for every turn of the wheel (72 ÷ 12=6).

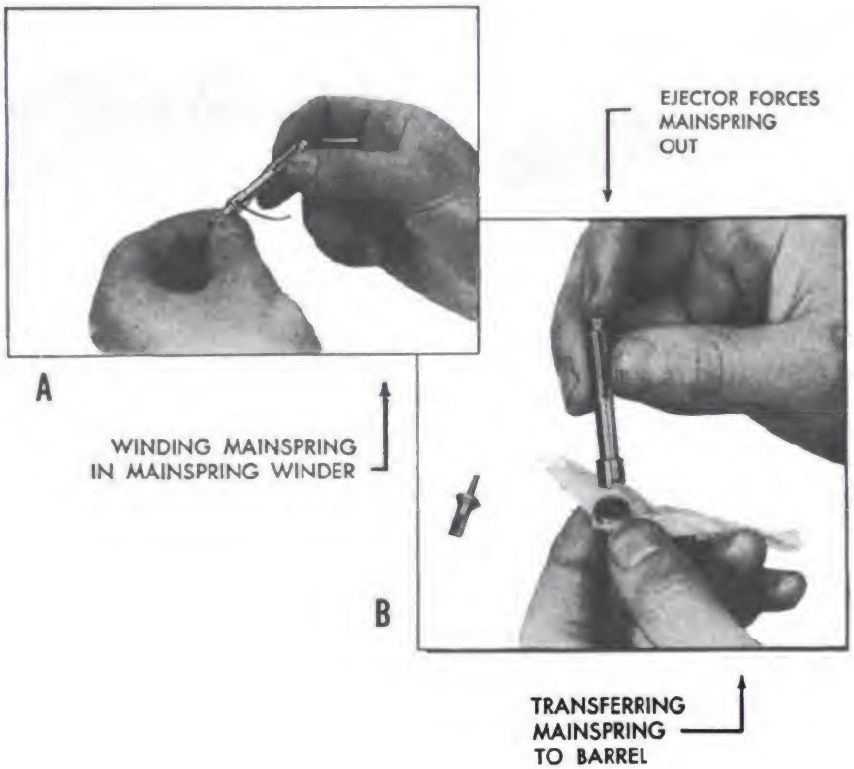

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Figure 7-18.—Procedure for inserting a mainspring into the barrel.

Turns of Main Train

Study figure 7-19. The wheels of the main train are identified by capital letters and the pinions by small letters, as follows:

B = barrel (first wheel)

C = center wheel (second)	c = center pinion (second)
T = third wheel	t = third pinion
F = fourth wheel	f = forth pinion
E = escape wheel	e = escape pinion

A watch train often has the following number of wheel teeth and pinion leaves:

$$\frac{B}{c} = \frac{72}{12} = 6 \qquad \frac{T}{f} = \frac{75}{10} = 7\ 1/2$$

$$\frac{C}{t} = \frac{80}{10} = 8 \qquad \frac{F}{e} = \frac{80}{8} = 10$$

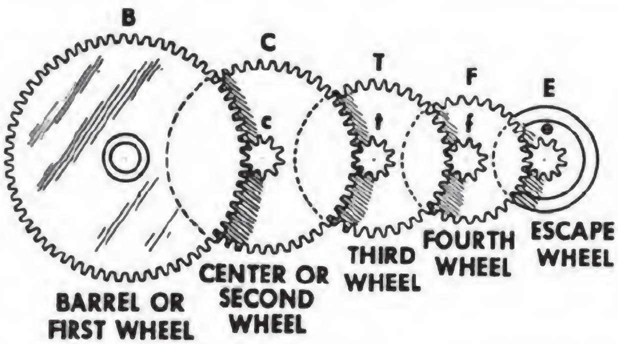
If you multiply the above quotients (6 x 8 x 7 1/2 x 10) you get 3,600, the number of turns the escape wheel makes each time the barrel makes a revolution. Divide 3,600 by 6 (number of turns center wheel makes to one turn of barrel) and you get 600, the number of turns the escape wheel makes per hour. These calculations are based on one turn of the center wheel and are represented by this formula:

$$\frac{C \times T \times F}{t \times f \times e} = 600$$

The second hand of a watch is secured to the arbor of the fourth wheel, which means that the fourth wheel makes 60 turns to each turn of the center wheel, as shown by the following formula:

$$\frac{C \times T}{t \times f} = \frac{80 \times 75}{10 \times 10} = 60$$

Most escape wheels have 15 teeth, and each tooth delivers two impulses when the watch is running—the first impulse to the receiving pallet, and the second impulse to the discharging



91.181
Figure 7-19.—Main train of a watch.

pallet. This means that the escape wheel delivers to the balance wheel twice as many beats as it has teeth. The formula which represents the beats is:

$$\frac{C \times T \times F \times 2 \times E}{t \times f \times e} = \text{Beats per hour, or}$$

in numerical values, it is

$$\frac{80 \times 75 \times 80 \times 2 \times 15}{10 \times 10 \times 8} = 18{,}000 \text{ beats per hour}$$

Number of Teeth in Lost Wheel

Suppose you receive in the instrument shop an unfamiliar watch which has a missing wheel or pinion. How can you calculate the number of teeth in the missing wheel, or leaves in the missing pinion? You can do this by using the following formula: (The fourth wheel, represented by F, is missing.)

$$\frac{80 \times 75 \times F \times 2 \times 15}{10 \times 10 \times 8} = 18{,}000$$

$$225\ F = 18{,}000$$

$F = 80$ (number of missing teeth in fourth wheel)

Suppose we take another example, the problem of finding the number of leaves in a missing third pinion. By using the following formula, with t representing the number of missing leaves, we get:

$$\frac{80 \times 75 \times 80 \times 2 \times 15}{t \times 10 \times 8} = 18{,}000$$

$$\frac{180{,}000}{t} = 18{,}000$$

$$18{,}000t = 180{,}000$$

$t = 10$ (number of leaves in third pinion)

THE ESCAPEMENT

A watch escapement is that unit of the watch which connects the wheel train assembly with the balance wheel assembly. Study the escapement illustrated in figure 7-20.

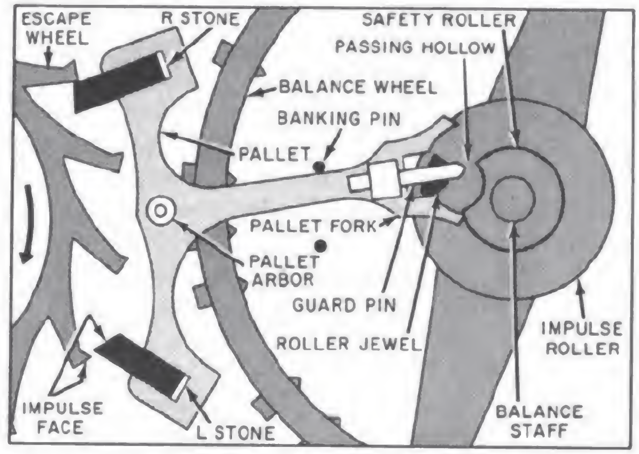


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Figure 7-20.—A watch escapement.

ESCAPEMENT TERMINOLOGY

To understand well the operation of a watch escapement, you need to know the following terms (names and functions of all parts of an escapement), as follows:

R or RECEIVING STONE—pallet stone which first meets or receives the escape tooth in an escapement action.

L or LET-OFF STONE—pallet stone which last makes contact with the escape tooth.

PALLET ARBOR—the staff on which the pallet swings.

FORK—part located at tail of pallet lever, containing slot which roller jewel enters. The fork delivers the impulse to the roller jewel.

HORNS—circular projections on each side of the fork slot which provide safety action during unlocking and impulse.

ROLLER JEWEL (also called jewel pin)—usually of ruby or sapphire and secured by shellac in a hole in the impulse roller table, the roller jewel is the connecting link between the pallet and the balance wheel.

ROLLER TABLE—flat, circular disk from which the roller jewel is suspended (and in which secured).

DOUBLE ROLLER—roller unit consisting of two metal disks. The upper disk (larger) supports the roller jewel and is known as the impulse roller. The lower disk (smaller) serves as the safety roller. (Has crescent notch.)

CRESCENT—notch in safety roller, to allow the guard pin to pass freely in either direction when the roller jewel is entering the fork.

GUARD PIN—small, brass pin below the fork. This pin serves as a safety device, ensuring that the pallet is in proper position to receive the roller jewel upon its return.

LOCK—amount of overlap between the pallet stone (jewel) and an escape wheel tooth.

LOCKING FACE—side of pallet stone which locks or overlaps a tooth of the escape wheel.

TOE OF TOOTH—corner of escape tooth which locks with the pallet stone.

HEEL OF TOOTH—corner of escape tooth, last part of tooth to leave pallet stone in an escapement action.

LET-OFF CORNER—extreme tip of pallet stone where tooth of escape wheel loses contact with pallet stone.

BANKING PINS—stops on each side of pallet which control distance pallet may swing.

IMPULSE—beginning at the instant of unlocking, the impulse is the drive of an escape wheel tooth against an impulse face of a pallet stone, causing the pallet to swing to the opposite direction (side). The pallet imparts this motion through roller jewel to the balance wheel.

IMPULSE FACE—inclined plane on the end of the pallet stone on which the escape wheel teeth press to produce the lift in an escapement action. The term impulse face may also refer to the plane on the end of a club tooth of the escape wheel.

DROP—free motion of the escape wheel when one tooth passes the let-off corner of a pallet stone and another tooth locks on the opposite stone.

BANKING TO A DROP—positioning of the banking pin to a point where the escape wheel teeth just clear or let-off the pallets.

DRAW—force exerted by an escape wheel tooth upon the locking face of a pallet stone, tending to bring the pallet lever against the banking pin.

SLIDE—space or distance a pallet stone travels downward on an escape wheel tooth immediately after the tooth comes to a lock with the pallet stone.

A watch movement which had only a train of wheels and a mainspring would run for a few moments at full speed when the mainspring was wound. The purpose of the escapement, therefore, is to check the speed of the train, to SLOW IT DOWN. The escapement allows each tooth on the escape wheel to pass at regulated intervals, which are measured and regulated by the balance assembly, without which the escapement could not operate.

The escape wheel, generally made of steel, is the last wheel of the train and is staked on a pinion and an arbor (fig. 7-20). It is so constructed that the pallet jewels move in and out between its teeth, allowing only one tooth to escape at a time.

The pallet jewels are set at an angle to make their inside corners reach over three teeth and two spaces of the escape wheel. The outside corners of the jewels reach over two teeth and three spaces of the escape wheel with a small amount of clearance. At the opposite end of the pallet, directly under the center of the fork slot is the guard pin (steel or brass). The fork is the connecting link to the balance assembly.

The escape wheel has 15 teeth and makes 600 revolutions per hour. During a revolution of the escape wheel, each tooth delivers TWO impulses to the pallet, or 18,000 impulses to the balance wheel. This means that the balance wheel vibrates 5 times per second, and that the power of the mainspring is arrested and released every 1/5th second by the locking and unlocking action of a pallet stone with an escape wheel tooth.

HOW AN ESCAPEMENT FUNCTIONS

The following discussion of the operation of an escapement is for one with fixed banking pins, with the roller jewel and both pallet stones correctly located. Before we start this discussion, however, it is best that we explain the

meaning of three distinct and different terms used in connection with the roller jewel. These terms are: (1) ROLLER JEWEL FREEDOM, (2) ROLLER JEWEL SHAKE, and (3) ROLLER JEWEL CLEARANCE.

Roller jewel freedom is the difference between the width of the pallet fork slot and the width of the roller jewel. Note the position and the amount of clearance of the roller jewel in figure 7-21.

Roller jewel shake is the space arrangement between the inside corners of the pallet fork and the front and back of the roller jewel at the instant of DROP, as shown in figure 7-22.

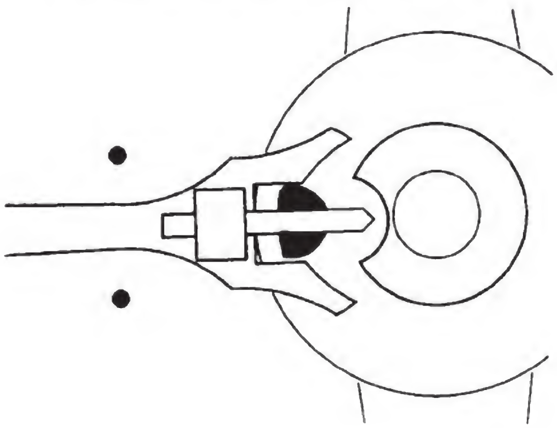

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Figure 7-21.—Roller jewel freedom.

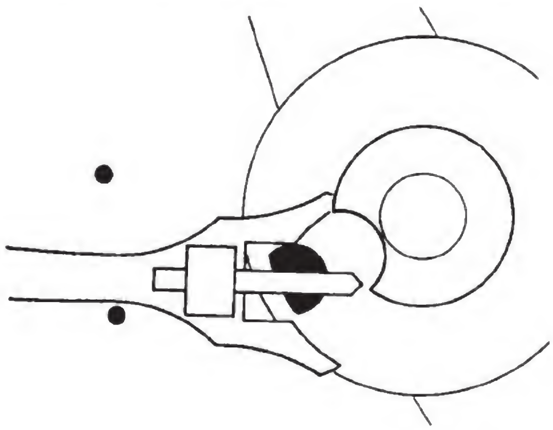

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Figure 7-22.—Roller jewel shake.

Roller jewel clearance (sometimes called fork horn clearance) is the clearance for the roller jewel in passing out and past the fork horns. See figure 7-23.

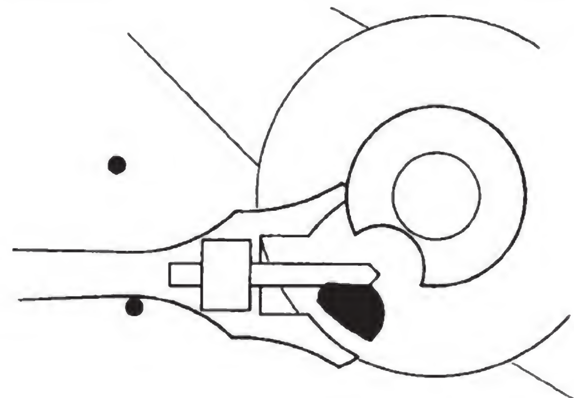

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Figure 7-23.—Roller jewel clearance.

You need to understand the action of the roller jewel, and the procedure for examining this action follows.

Roller Jewel Freedom

Select a good loupe and examine the action of an escapement. Move the balance wheel slowly with the index finger until the roller jewel enters the fork slot. Note that this movement unlocks the escape wheel tooth. At the instant of unlocking of the tooth, the impulse action begins, as illustrated in figure 7-24.

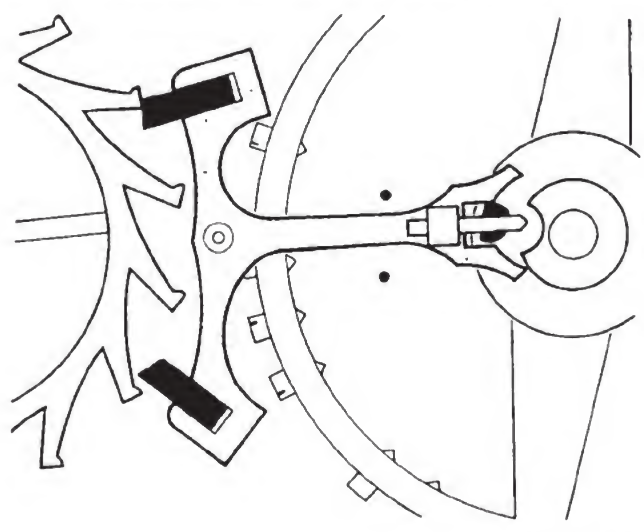

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Figure 7-24.—Unlocking of an escape wheel tooth.

Next, turn the balance wheel slowly enough to enable you to observe the travel of the escape wheel tooth across the pallet stone (fig. 7-25).

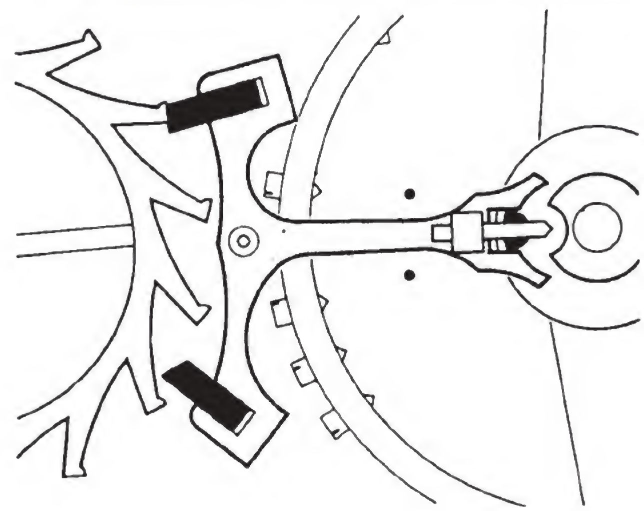

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Figure 7-25.—Slide of escape wheel tooth across a pallet stone.

Observe the position of the roller jewel while the slide is taking place. At the exact instant of the drop of the tooth from the pallet stone another tooth LOCKS on the other pallet stone (fig. 7-26).

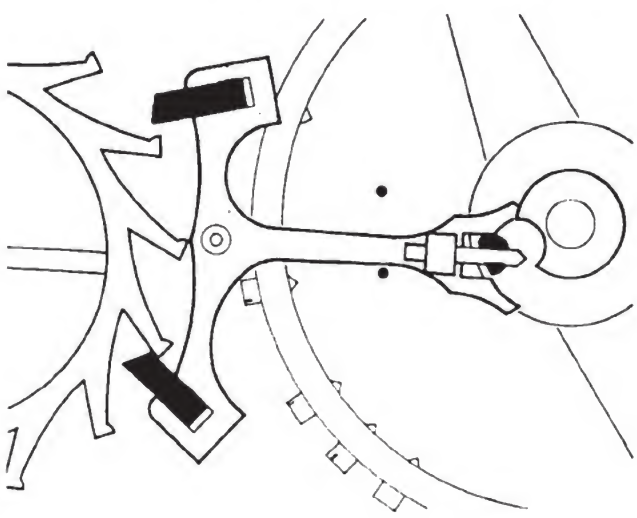

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Figure 7-26.—DROP and LOCK of escape wheel teeth.

Roller Jewel Shake

By stopping the motion of the balance wheel at the exact instant of the LOCK and the DROP, you can check for roller jewel shake. Move the fork back and forth with an escapement trying tool or a pivot broach. This action causes corner A (fig. 7-27) of the fork slot to touch the back side of the roller jewel and corner B to touch the flat face of the roller jewel. The fork has not yet touched the banking pin.

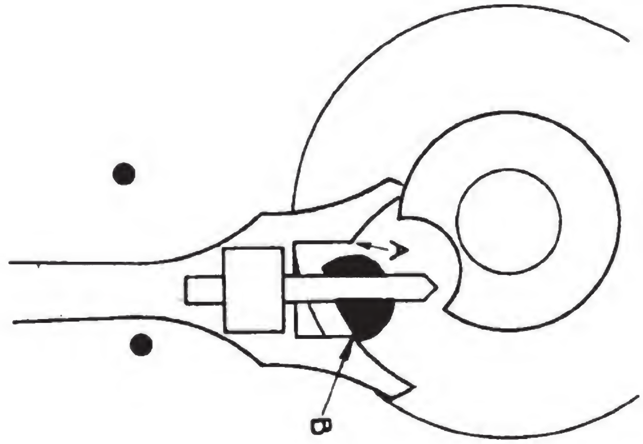

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Figure 7-27.—Checking roller jewel shake.

Now, reverse the motion of the balance wheel, to allow the roller jewel to move the fork enough to unlock the escape wheel tooth. The impulse now begins; and when it is completed, the drop occurs, at which time the escape wheel again comes to lock. Study this action in parts A, B, and C of figure 7-28.

At this point, recheck for roller jewel shake. Observe that the shake is equal on both sides, indicating that the fork moves as far on one side of the center line as on the other side.

Roller Jewel Clearance

After you check the escapement for roller jewel shake, examine the CLEARANCE of the roller jewel as it completely passes out of the fork slot. Turn the balance wheel slowly with the index finger and observe the roller jewel as it gradually passes out of the fork slot and past the fork horn.

As the roller jewel passes the fork horn, check for clearance. Study figure 7-29, which shows the fork against the banking pin at A and the amount of clearance between the roller jewel and the fork horn.

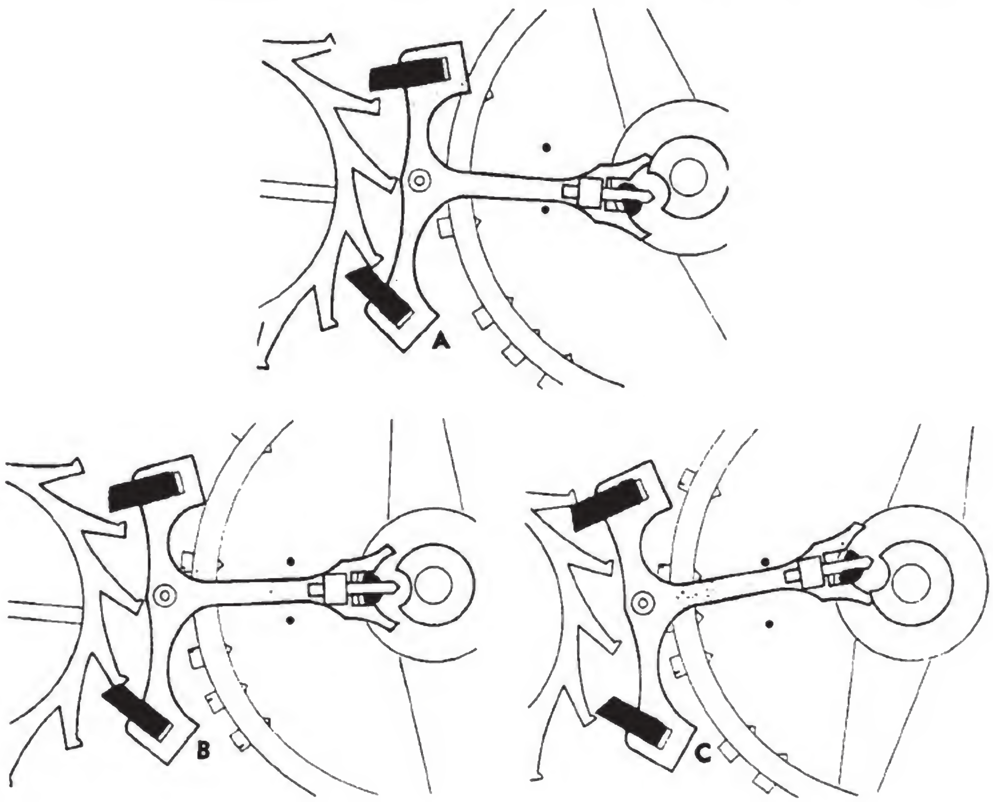

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Figure 7-28.—Checking roller jewel shake (with motion of balance wheel reversed).

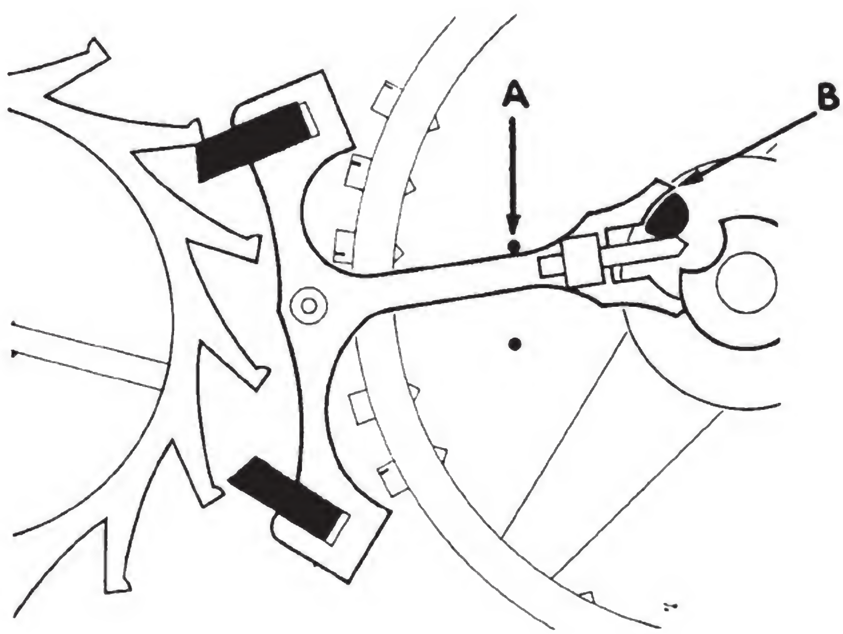

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Figure 7-29.—Checking roller jewel clearance.

Guard Pin Shake

Guard pin shake is the distance between the guard pin and the safety roller when the fork rests against the banking pin. This distance should be SLIGHTLY LESS than the lock.

Check for guard pin shake after the roller jewel passes out of the fork slot and beyond the fork horn. See figure 7-30, which shows the roller jewel completely out of the fork and the guard pin pressed against the safety roller. The escape wheel tooth is still safely locked on the pallet stone. Note that the fork is NOT against the banking pin. When it does touch the banking pin, there will be a little space between the guard pin and the safety roller.

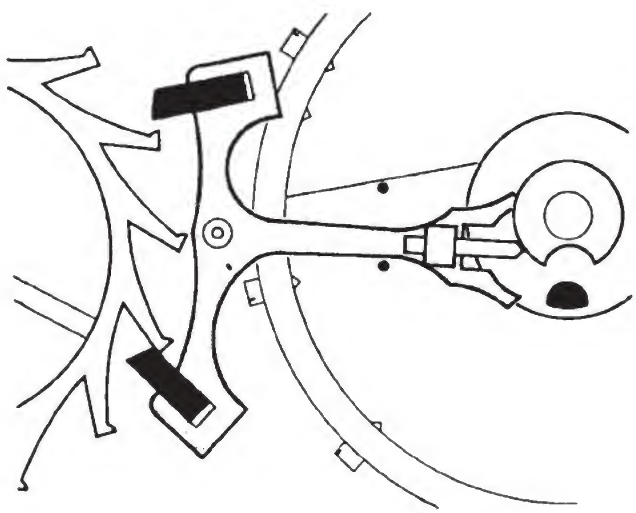

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Figure 7-30.—Checking guard pin shake.

Checking the Draw

The function of the draw (draft) on the pallet stone and the escape wheel teeth is to hold the fork securely against the banking pin during the passage of the roller jewel from the fork slot.

Check the draw at the SAME TIME you test for guard pin shake. When the guard pin touches the safety roller, quickly release the fork and the draw will start. It will immediately pull the guard pin away from the roller and hold the fork against the banking pin.

Testing the Slide

The space a pallet stone travels DOWNWARD on an escape wheel tooth after the lock occurs is called THE SLIDE. Test the slide of the pallet stone on an escape wheel tooth by quickly moving the roller jewel away from the position where you checked the roller jewel shake, and AWAY from the LINE OF CENTERS.

Banking to a Drop

BANKING TO A DROP is another method for checking a watch escapement, based entirely on movable banking pins with which millions of watches were originally provided. Because many of these watches are still in use, it is essential that you understand the meaning of BANKING TO A DROP, which can be considered as the basic reference for checking the LOCK, DROP, ROLLER JEWEL SHAKE, and GUARD PIN SHAKE. Make the tests in the following order:

1. Remove the balance wheel and turn the L banking pin as close as possible to the LINE OF CENTERS. The fork now rests against the L banking pin, held by the power of the mainspring transmitted through the main train to the impulse faces of the escape wheel teeth and the pallet stones. See figure 7-31.

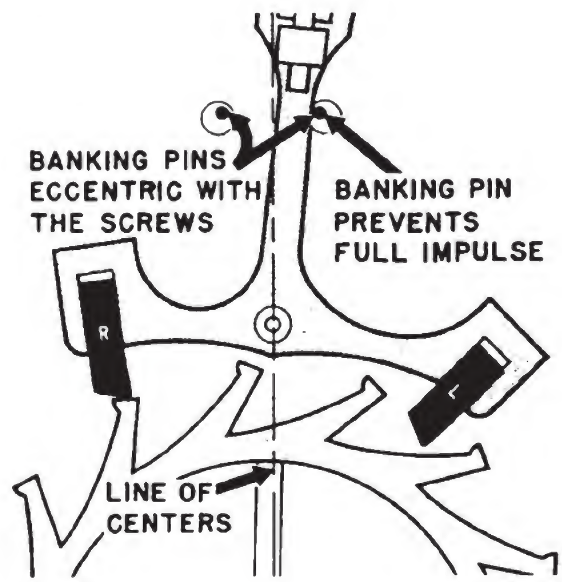

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Figure 7-31.—First step in BANKING TO A DROP.

2. With the watch held DIAL DOWN in the left hand, turn the screw against which the fork rests away from the line of centers.

3. With a good loupe, observe the movement of the impulse face of the escape wheel

tooth across the impulse face of the pallet stone. As soon as the impulse face of the escape wheel tooth drops off the R pallet stone, another tooth locks itself on the L stone. The lock is about 1/4 the width of the impulse face of the pallet stone. (You are interested in the AMOUNT OF LOCK just after an escape tooth loses contact with a pallet stone.) Turn the eccentric banking pin screw JUST ENOUGH to allow a tooth to escape a pallet stone (fig. 7-32). Bear in mind that the location of the banking pins is determined by the position of the pallet stones. The farther OUT the pallet stones are, the farther AWAY from the line of centers must the eccentric banking pin be moved before a tooth escapes.

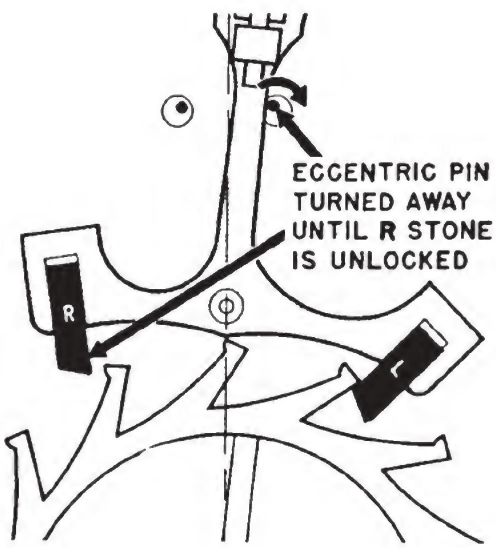

Figure 7-32.—Second step in BANKING TO A DROP.

4. Turn the R banking pin so that it is as close as possible to the line of centers. The fork must be moved so that it rests against the R banking pin, as illustrated in figure 7-33.

5. Now turn the screw for the R banking pin just enough to allow the escape wheel tooth to drop off the L pallet stone (fig. 7-34). The fork must then be moved back and forth until the escape wheel makes one complete turn. The pallet may now be considered as BANKED TO THE DROP. When this is so, the fork moves an equal distance from each side of the line of centers (fig. 7-35).

6. From here on, with the balance wheel and hairspring unit in the watch, check the lock, drop, roller jewel shake, and guard pin shake as you did for a watch with fixed banking pins. Guard pin shake at this point is barely noticeable, not more than 1/2 degree in a light lock. As the lock is increased, more guard pin shake is permissible, as much as 1 degree.

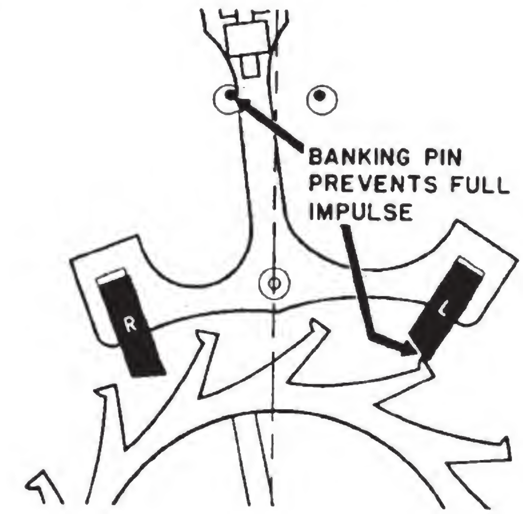

Figure 7-33.—Third step in BANKING TO A DROP.

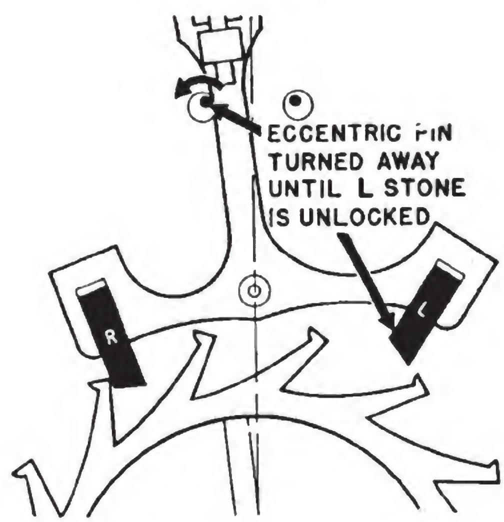

Figure 7-34.—Fourth step in BANKING TO A DROP.

7. When the lock, drop, guard pin shake, and roller jewel shake are satisfactory, turn both banking pins away from the line of centers to check THE SLIDE. Study figure 7-36. Turn the pins just enough to allow an increase of

about 1/3 the lock established when banking to a drop. You will now find that guard pin shake has been slightly increased on both sides.

Turn the balance wheel carefully with the index finger and observe the slide. Immediately after the drop, as you turn the balance farther away from the line of centers, the pallet jewel moves down (slides) a short distance on the escape wheel tooth. Slide is present on each tooth of the escape wheel.

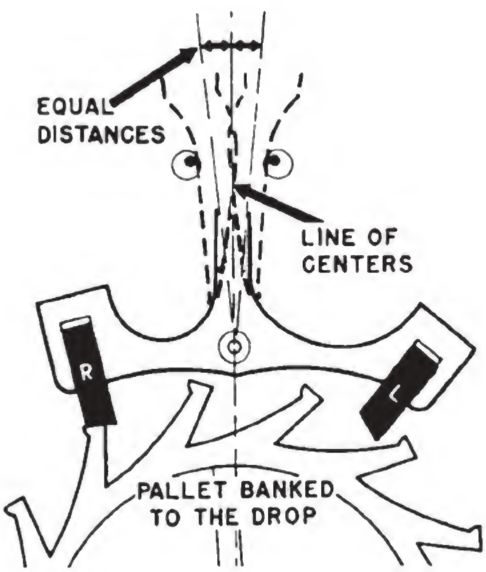

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Figure 7-35.—A watch pallet BANKED TO A DROP.

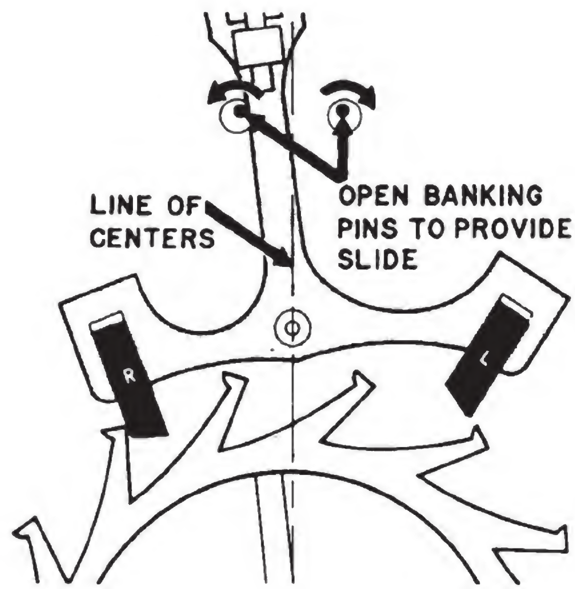

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Figure 7-36.—Checking THE SLIDE.

REPAIRING THE ESCAPEMENT

On occasions, you will have the responsibility for repairing or replacing major parts (escape wheel, pallet, and roller) of an escapement. This section takes into consideration the procedure for doing this work, and it also explains how to position the pallet stones in order to have the escapement function properly.

The tools you need for repairing an escapement are shown in figure 7-37.

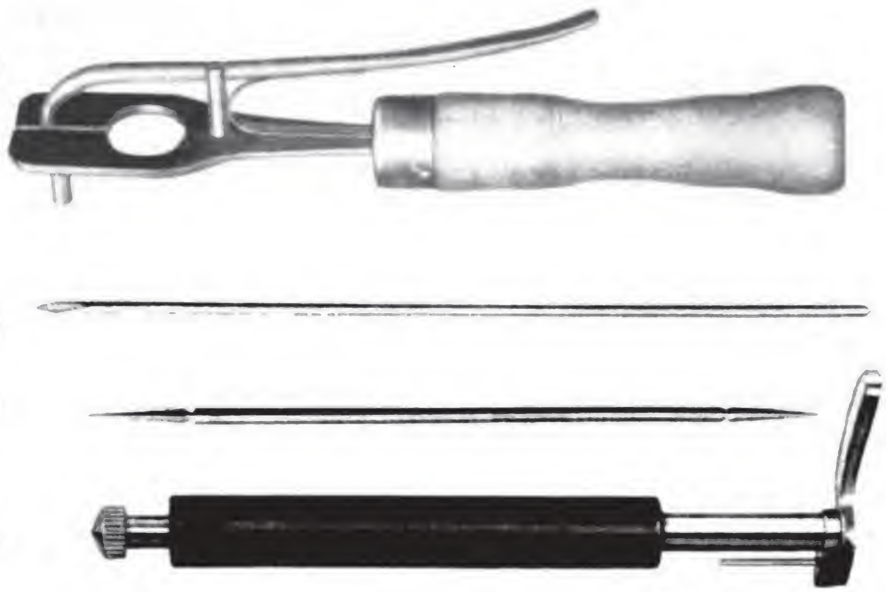
Replacing a Roller Jewel

The procedure for installing a new roller jewel is as follows:

1. Check the size of the jewel in the fork of the pallet. A jewel too large will not fit, of course, and a jewel too small causes lost motion of the pallet. There should be a roller jewel clearance (freedom) of .01 mm. for small watches, and .03 mm. for 16-size watches. A roller jewel must also have correct length, as shown in figure 7-38.
2. Thoroughly clean the roller jewel hole with alcohol, so that shellac will adhere to its surface (all around).
3. Use tweezers to insert the roller jewel into the hole in the roller. To prevent breakage of the jewel, be careful about the amount of pressure you exert on the tweezers.
4. Place the roller (with or without balance wheel attached) in the jewel pin warmer and heat the warmer over an alcohol lamp. Study figure 7-39.
5. As the pin warmer is heating over the alcohol lamp, apply a piece of string shellac on top of the impulse roller, directly over the jewel (fig. 7-39). At this point, make certain that the jewel is perpendicular to the roller (before it sets).
6. Dip a piece of pegwood in alcohol and remove the excess shellac.
7. After the shellac has had time to harden around the jewel, put the balance assembly in the watch and check its action with the fork of the pallet.

Installing a Pallet Arbor

Pallet arbors are of two types, friction-fitted and screw. To remove or to install a friction-fitted arbor, use a staking punch, as



1. Pallet warmer.
2. Pallet stone pusher.
3. Escapement tool.
4. Jewel pin warmer.

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Figure 7-37.—Tools used for repairing an escapement.

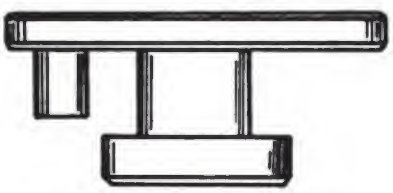

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Figure 7-38.—Proper length for a roller jewel.

shown in figure 7-40. Note the size of the hole in the flat-faced punch, and also the size of the hole in the stump. The hole in the punch should be slightly larger than the pivot rests on the shoulder of the arbor.

The pallet is usually positioned slightly below the upper pivot of the arbor, but it can be shifted to any height.

A screw-type pallet arbor (fig. 7-41) is threaded on its upper shoulder and can be screwed into the pallet. Figure 7-41 shows how the arbor can be screwed in or out with a pin vise. Observe that the pin vise is secured to the lower shoulder of the arbor.

Fitting a New Guard Pin

Remove the old guard pin in the manner illustrated in figure 7-42. Cut off the small end and then push it out with a pair of pliers or tweezers.

Insert a new guard pin in the opposite direction; that is, from the pallet side. Force the pin friction-tight with a pair of tweezers. If you do not have a new guard pin available, insert a piece of thin brass wire into a pin vise and roll-file it on a boxwood slip to a fine taper. Then burnish the pin.

After you have inserted the new pin, clip it off with pliers. Allow just enough length for finishing. Finish the tip of the pin with an oilstone slip in the manner shown in figure 7-43. The point of the pin should be so filed that it makes a 90° angle, as illustrated.

Now test the pallet in the watch. If the guard pin shake is excessive, lengthen the pin by pressing the thick end closer to the fork. If the pin is too long, use an oilstone slip to shorten it, still retaining the 90° angle on the end.

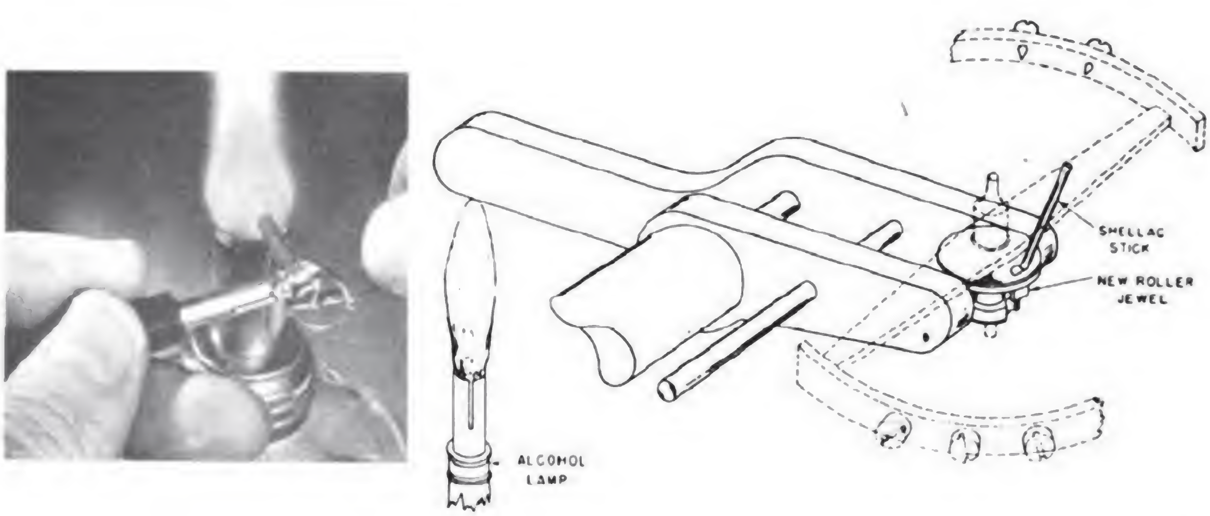

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Figure 7-39.—Inserting a roller jewel.

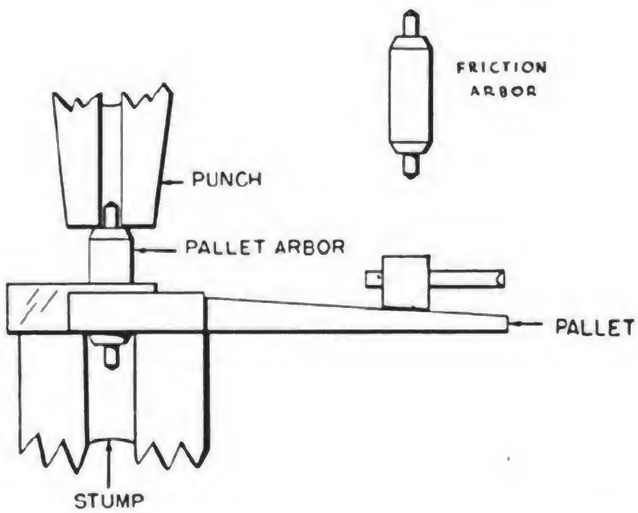

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Figure 7-40.—Replacing a friction-type pallet arbor.

Straightening the Pallet Lever

You can straighten a bent pallet lever by placing the pallet on a boxwood slip, with the arbor inserted in a hole, and striking the bent shank with tweezers until you have it in its original level condition. Study the procedure for doing this in figure 7-44.

Moving Pallet Stones

If one pallet stone is moved OUT (toward an escape wheel tooth), it causes the pallet fork to swing a greater distance from the line of centers before the lock occurs on the opposite stone. If one pallet stone is moved IN (away from an escape wheel tooth), the distance the pallet swings from the line of centers before locking with the other stone is reduced.

Because the movement of a pallet stone affects the distance the pallet moves, when one

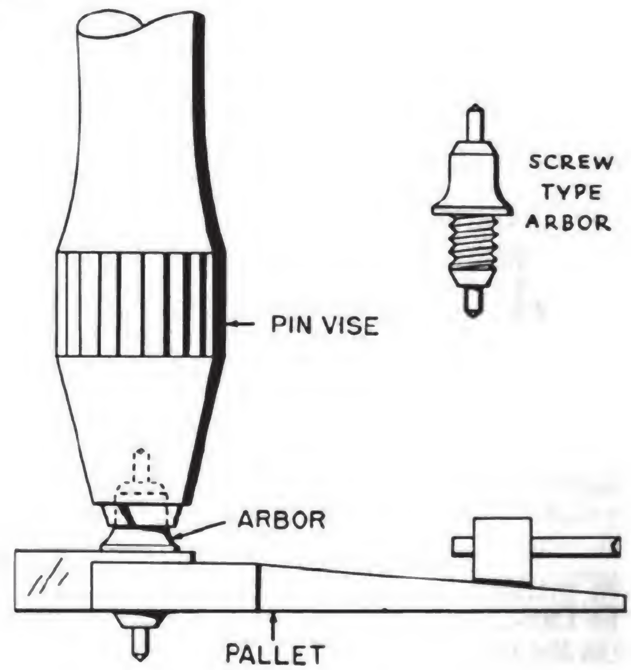

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Figure 7-41.—Installing a screw-type pallet arbor.

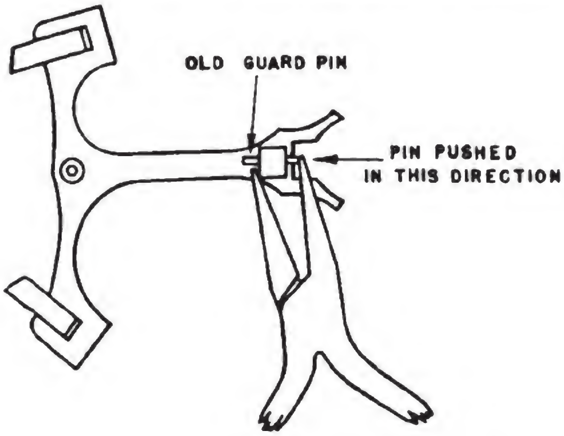

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Figure 7-42.—Fitting a new guard pin.

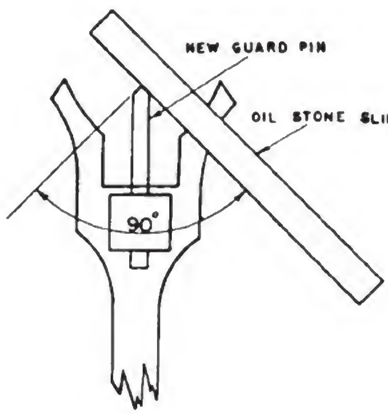

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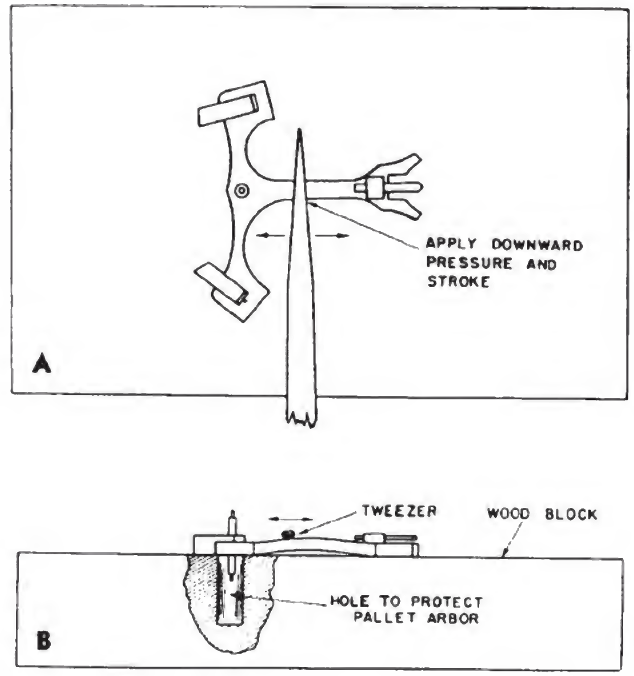
Figure 7-43.—Putting a 90° angle on a guard pin point.

stone is moved OUT or IN (causing the lock to be increased or decreased) the lock on the opposite stone is increased or decreased by the same amount. For example, if you move the R stone out a small amount, you increase the lock on the L stone the same amount. At the same time, the pallet moves closer to the L banking pin at the instant of lock, permitting less slide. See figure 7-45.

When you must move a pallet stone out or in, proceed as follows:

1. Remove the pallet from the watch and place it upside down on a pallet warmer, with the lower pivot placed in the hole provided in the movable arm.

2. Warm the shellac holding the pallet stones by heating the pallet warmer over an al-



91.200X
Figure 7-44.—Straightening a pallet lever.

cohol lamp. CAUTION: Overheating causes shellac to spoil.

3. Remove the pallet warmer from the lamp, and remove the pallet stone(s) in or out with a nickel or brass tool (fig. 7-37).

4. Remove the pallet from the warmer. Lift straight up in order to keep the stones level with the body of the pallet.

5. Dip a piece of pegwood in alcohol and remove the excess shellac.

6. Replace the balance wheel in the watch and determine the amount of travel of the pallet from the line of centers by testing the roller jewel shake. If the distance of the pallet from the line of centers is greater than before at the instant of lock, the roller jewel shake has increased. If the pallet is closer to the line of centers at the instant of lock, the roller jewel shake has decreased.

PALLET STONE RULE: If the lock is TOO LIGHT, pull OUT the stone opposite the LESSER jewel pin shake. If the lock is TOO STRONG, push IN the stone opposite the GREATER jewel pin shake.

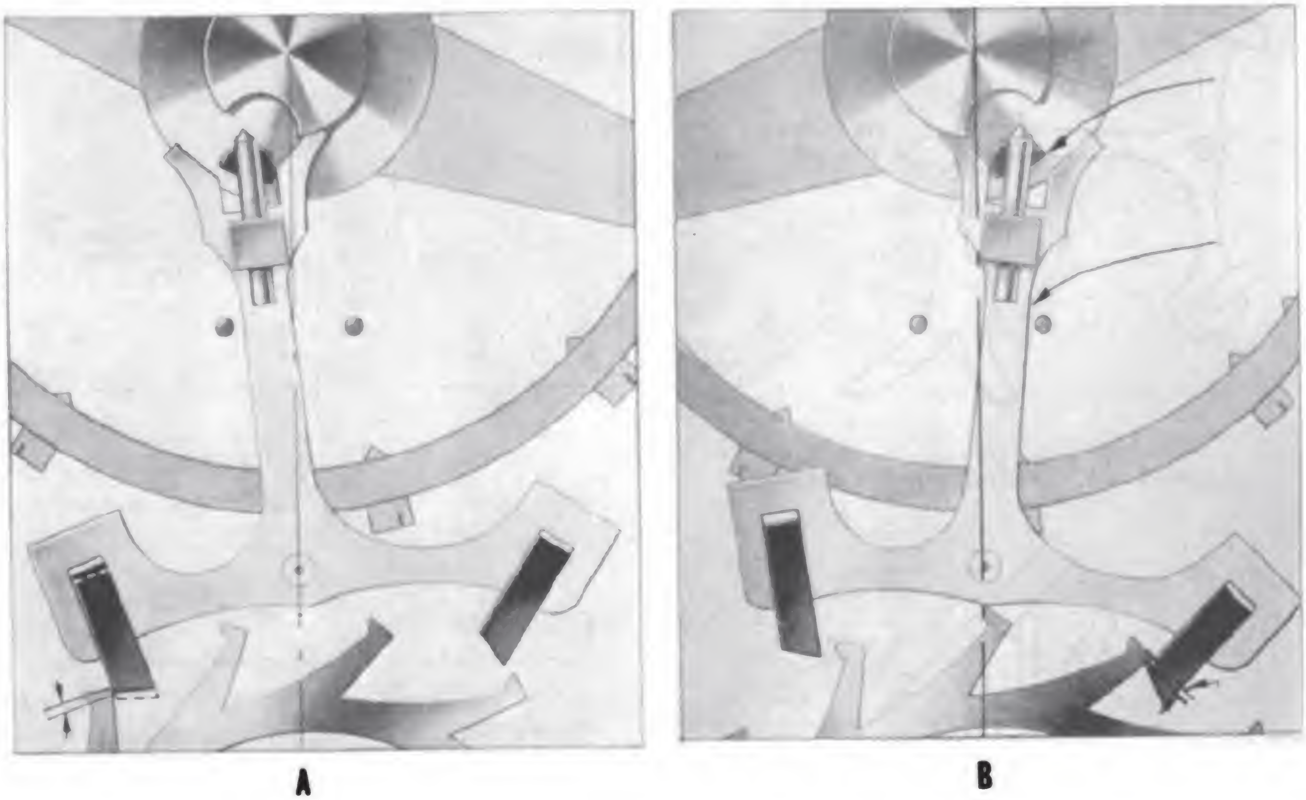


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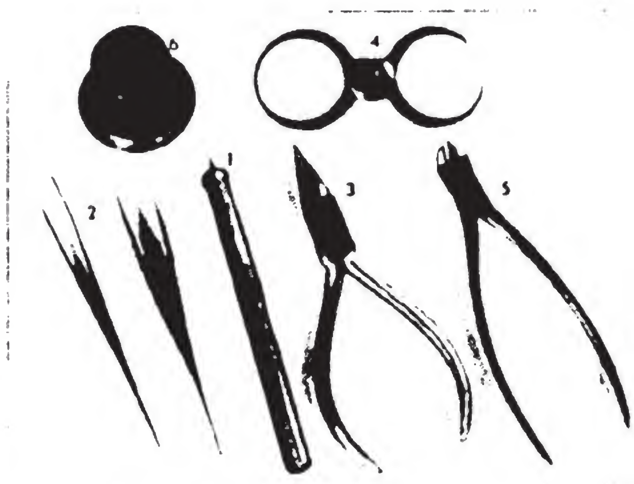
Figure 7-45. —How the moving of a pallet stone affects LOCK and SLIDE.

CHAPTER 8

MANIPULATION OF HAIRSPRINGS

In this chapter we discuss the procedures for manipulating hairsprings used in barometers, dial indicators, watches, and clocks. The word MANIPULATION, when used in connection with hairsprings, refers to such things as: (1) determining the strength of a hairspring, (2) pinning a hairspring in a collet, (3) overcoiling a hairspring, (4) vibrating a hairspring, and (5) truing a hairspring.

Before you can qualify for advancement to an Instrumentman 1, you must be able to true a pressure gage hairspring in the flat and in the round; and before you can qualify for the rate of a Chief Instrumentman you must know how to do everything listed in the first paragraph. By studying this chapter, you will learn the basic principles for manipulating hairsprings. Through actual experience in Navy instrument shops, you will learn how to accomplish all phases of hairspring manipulating.



1. Colleting arbor.
2. Tweezers.
3. Snipe-nose pliers.
4. Hairspring-truing calipers.
5. Side-cutting pliers.
6. Loupe

1.21X

Figure 8-1.—Tools used in manipulating hairsprings.

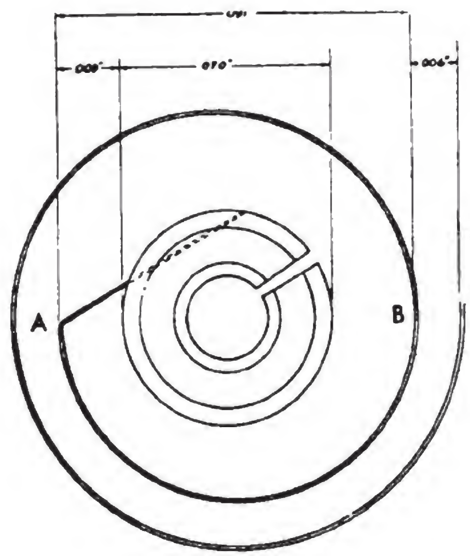
COLLETING

The inside coil of a hairspring must be attached to a collet which fits snugly on the top shoulder of the balance staff. The procedure for doing this is known as COLLETING. Colleting is delicate work which requires skillful use of proper tools: colleting arbor (tool for holding the collet), 3-power loupe, pair of cutting pliers, pair of long-nose pliers, pair of regular over-coiling pliers, and two pairs of fine steel tweezers. These tools are illustrated in figure 8-1. CAUTION: Some Instrumentmen like to use a high-power loupe for doing this work, but continual use of such a loupe causes eye strain.

REMOVAL OF INNER COILS

The first principal step in colleting is the removal of as much of the inner end of a hairspring as is necessary to make room for the collet. This means that you must break out an inner coil(s) of the hairspring.

When a collet is placed in the center of a hairspring, the space from the edge of the collet to the first inner coil is 1 1/2 times as great as the space between any other coils in the spring. For example, if the collet diameter is 0.070 inch, which is true of the collet shown in figure 8-2, and the space between the coils is 0.006 inches, the distance between point A and point B should be 0.091 inch. Note that the distance between point B and the second coil is 0.006 inches, and that the distance between the collet and point A is 0.009 inches. This means that this collet is correctly positioned in the middle of the hairspring.



91.202X
Figure 8-2.—Inner coil dimensions of a hairspring.

To break out the inner coils of a hairspring, proceed as follows:

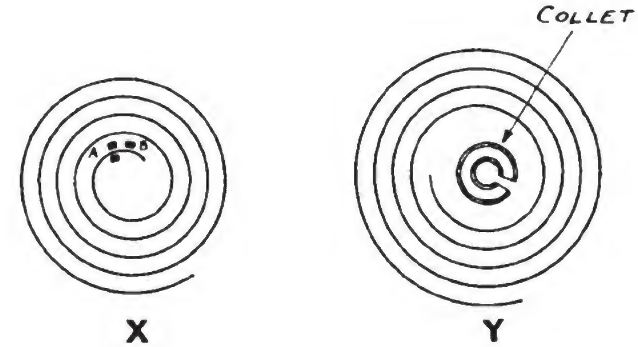
1. Measure the diameter of the collet.
2. Measure the distance between coils in the spring.
3. Select a spot on a coil where the distance between the spot and the collet is 1 1/2 times the distance between any two coils of the spring.
4. With a pair of tweezers, grasp the coil at the selected spot and exert enough pressure to prevent slippage. See A in part X of figure 8-3.
5. With another pair of tweezers, grasp the coil to be broken at point B (part X, fig. 8-3) and pull out as far as necessary to break it. Another way to break the coil is to bend it back and forth.
6. Put the collet back in the middle of the hairspring and check measurements for accuracy (part Y, fig. 8-3).

FORMING THE TONGUE

The SECOND STEP in colleting is making the tongue, which is that portion of the inner coil (line AB in part W of fig. 8-4) which fits in the pin hole in the collet.

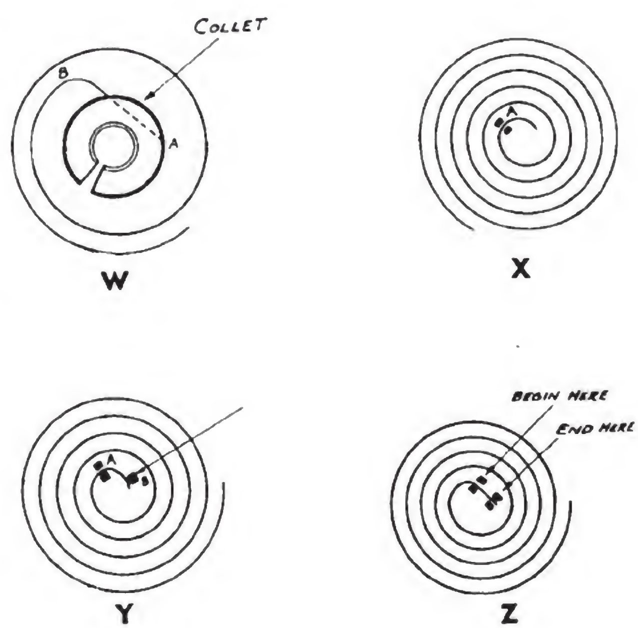
The following procedure for forming a tongue on the inner coil of a hairspring is recommended:

1. Lay the hairspring flat on a bench.
2. Grasp the inner coil with a pair of tweezers at point A (part X, fig. 8-4).



91.203X
Figure 8-3.—Procedure for breaking out the inner coil.

3. With a second pair of tweezers, grasp the end of the coil at B (part Y, fig. 8-4) and bend the coil in the direction indicated by the arrow. Avoid a sharp bend at point A. With experience, you will learn the CORRECT AMOUNT of bend to put on the coil at this point.
4. Straighten the tongue by grasping it with one pair of tweezers at the point indicated by BEGIN HERE in part Z of figure 8-4 and by straightening it out gradually with another pair of tweezers between the BEGIN HERE and END



91.204X
Figure 8-4.—Forming the tongue on a hairspring.

HERE points. Use gentle pressure with the second pair of tweezers, and pinch and pull on the coil until you have it perfectly straight. This is not a difficult task, but it does require care.

PINNING-IN

Pinning-in is the process of fastening the hairspring to the collet. The procedure for doing this follows:

1. Place the collet on a colleting arbor with the top of the collet facing up and the pinhole facing you. Study parts W and X of figure 8-5.
2. Grasp the inner coil with a pair of tweezers just back of the bend made to form the tongue (B in part Y, fig. 8-5) and bring the spring down over the top of the colleting arbor, with the tongue in direct line with the collet pin hole (D in part X, fig. 8-5).
3. Grasp the colleting arbor with the left hand and turn it counterclockwise to the extent necessary to bring the pin hole of the collet into direct line with the hairspring tongue (part Z, fig. 8-5).
4. Hold the colleting arbor firmly with the left hand and insert the tongue in the pin hole. Use the thumb and first finger of the right hand to support the hairspring and to prevent it from tipping. CAUTION: Do NOT distort coils in the spring.

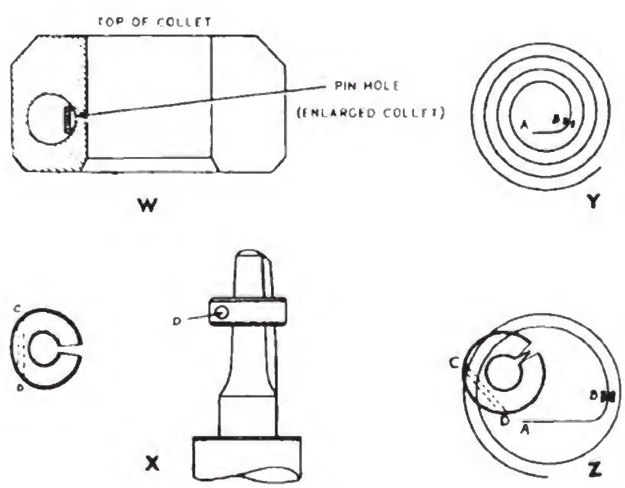


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Figure 8-5.—Inserting hairspring tongue in a collet.

5. Grasp the big end of a tapered brass pin with a pair of tweezers and insert it in the collet pin hole at D (fig. 8-6). Push the pin in tight enough to hold it in position.
6. Measure the distance between the collet and point B (fig. 8-6), and also the distance between point B and the second coil in the spring. If the distance between B and the collet is 1 1/2 times the distance between B and the second coil, the tongue is correctly pinned in the collet hole.
7. If the tongue is not correctly pinned, loosen the metal pin sufficiently to enable you to move the tongue IN or OUT, as necessary. Your measurements must be accurate.

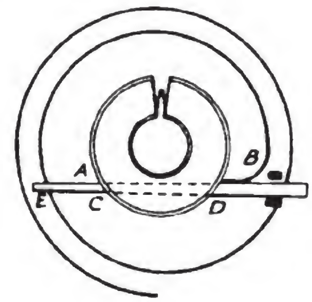

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Figure 8-6.—Pinning hairspring tongue in a collet.

TIGHTENING PIN IN COLLET

The procedure for tightening the tapered metal pin in the collet hole is as follows:

1. With a pair of snipe-nose pliers, grasp the small end of the tapered pin and pull it tight, using a pulling and twisting motion. Study figure 8-7.

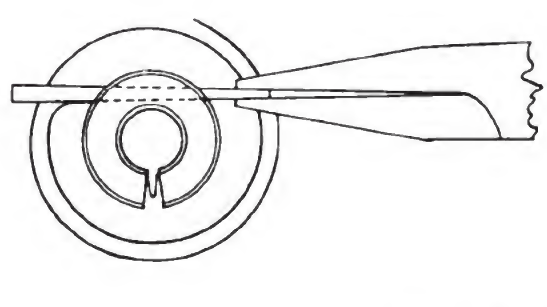

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Figure 8-7.—Tightening the brass pin in a collet.

2. Turn the colleting arbor in a clockwise direction until you have formed a 90° bend in the pin. (Fig. 8-8 top.)

3. Turn the arbor in a counterclockwise direction until the pin breaks off. (Fig. 8-8 bottom.)

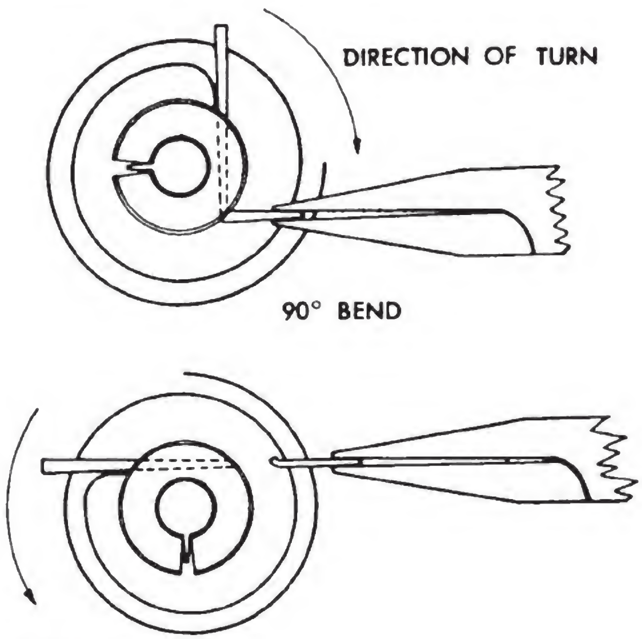

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Figure 8-8. —Breaking off the ends of a colleting pin.

4. To break off the large end of the colleting pin, make the 90° bend by turning the arbor in a COUNTERCLOCKWISE direction and break the pin off by turning the arbor in a CLOCKWISE direction.

Before you remove the collet and hairspring from the colleting arbor, make a check to determine whether: (1) both ends of the colleting pin are broken off cleanly at the collet, (2) the pin is tight in the collet hole, and (3) any inside coils are bent or distorted. CAUTION: If inside coils are bent or distorted in any manner, discard the spring.

STAKING COLLET ON BALANCE STAFF

The five steps discussed next are recommended for staking a collet on a balance staff. Use a staking stand.

1. Select a stump with a hole slightly larger than the roller shoulder of the staff, but smaller than the roller table seat (fig. 8-9).

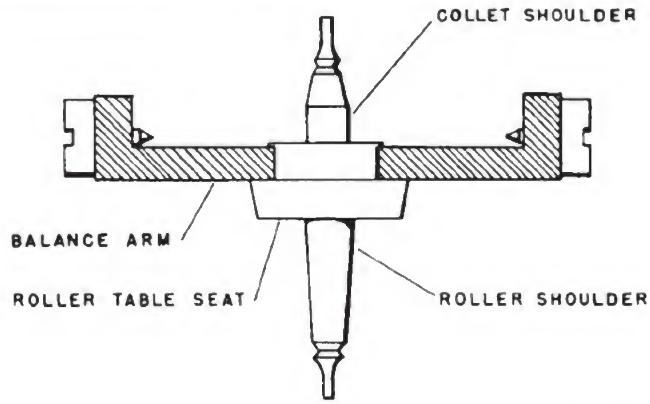

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Figure 8-9. —Nomenclature of a balance assembly.

2. Place the selected stump in the staking table and insert the balance staff in the stump, as shown in figure 8-10.

3. Select a staking punch with a hole slightly larger than the collet shoulder of the balance staff, but smaller than the outside diameter of the collet (fig. 8-10).

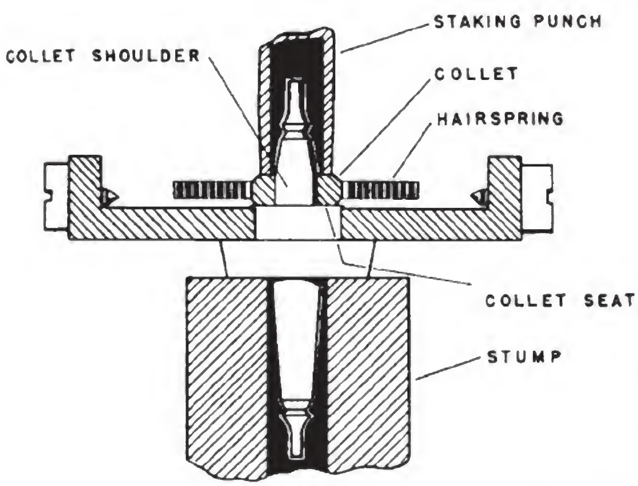
4. Lay the hairspring and collet on the balance staff with the top side of the collet up, and position the spiral of the spring counterclockwise from the pinning point.

5. Bring the staking punch down on the collet and gently force the collet onto the collet shoulder to seat it firmly. Study figure 8-10. The friction between the collet and the collet shoulder must always be sufficient to hold the spring in place.

When you finish the staking process, dip the entire assembly in a good cleaning solution and properly rinse it. Next, dip the assembly in alcohol and dry it in a box containing wood sawdust. Then put the balance unit in calipers and remove small particles of sawdust with a camel's hair brush.

HAIRSPRING TRUING

Hairspring truing is the procedure of locating the collet so that it is flat and exactly in the center of the coils of a hairspring. This operation is necessary to correct errors resulting from the breaking out of coils, forming the tongue, and pinning the tongue in the collet hole. Attaching the hairspring to the collet requires so much skill that it is almost impossible to do it without the introduction of errors. The following discussion tells you how to locate

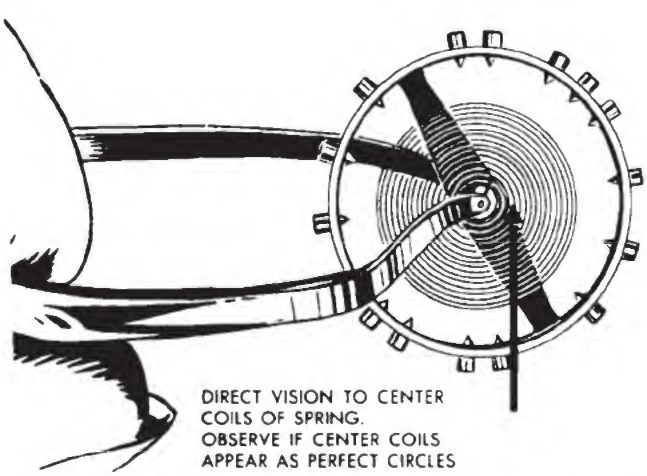


91.210X
Figure 8-10.-Collet forced into position with a staking punch.

and how to eliminate these errors. There are generally two types of errors in a hairspring: (1) errors in the round, and (2) errors in the flat. These are discussed separately.

ERRORS IN THE ROUND

To check a hairspring for errors in the round, secure the balance wheel and hairspring in calipers in the manner illustrated in figure 8-11 and observe the action of the spring as you slowly rotate the balance wheel with the side of the index finger. If the first three or



91.211X
Figure 8-11.—Checking a hairspring for errors in the round.

four inside coils appear as perfect circles, the hairspring is TRUE IN THE ROUND. If the coils seem to jump or describe irregular circles as the balance wheel rotates, there is an ERROR IN THE ROUND.

Turn now to figure 8-12 and check some hairsprings which have errors in the round. The first part of this illustration shows a hairspring which is true in the round, so compare all the other hairsprings in the illustration with this one. The type of error for each hairspring is listed beneath it. Pay particular attention to the DEGREE OF ERROR IN THE ROUND in each hairspring.

After you locate errors in the round in a hairspring, your next task is to eliminate them by bends properly made in the coils of the hairspring. You can make these bends while the balance wheel is supported in calipers. Make them on the 1/8th part of the first coil near the elbow of the bend made to form the tongue.

Study next figure 8-13, which shows the procedure for correcting an error in the round as a result of the tongue's having been INSERTED IN TOO FAR in the collet hole. To correct this error, do the following:

1. Grasp the inside coil with tweezers at point A (part X, fig. 8-13) and bend the coil AWAY from the collet, as indicated by the arrow.

2. Grasp the inside coil at point B (part Y, fig. 8-13) and bend the coil TOWARD the collet. When you finish with this bend, the position of the collet with respect to the coils of the spring should be as indicated in part Z of figure 8-13.

If you pin the tongue of a hairspring TOO FAR IN the collet, the hairspring will have an error in the round. Make correction by bending the inner coil in the manner described in the next two steps.

1. Place the tweezer points on the collet and the elbow of the tongue at the spots indicated by A and B in part X of figure 8-14 and gently squeeze IN on the coil at point B, as indicated by the arrow.

2. Grasp the inside coil at point C (part Y, fig. 8-14) and bend the coil AWAY FROM the collet. Part Z of figure 8-14 shows the results of your bending.

On occasions, an error in the round of a hairspring is caused by NOT BENDING THE TONGUE ENOUGH AT THE ELBOW. You can correct such an error by grasping the inside coil with a pair of tweezers at point A (part Y, fig. 8-15) and by bending the coil TOWARD THE

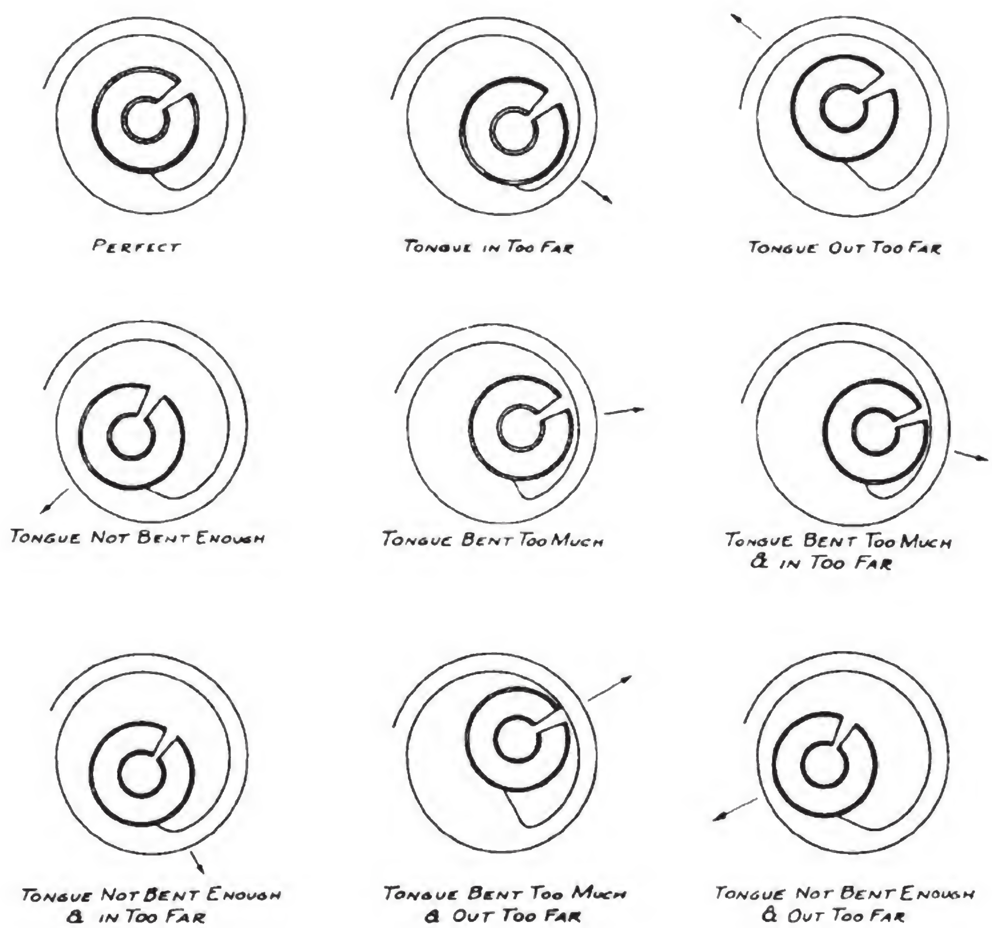


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Figure 8-12.—Typical hairspring errors in the round.

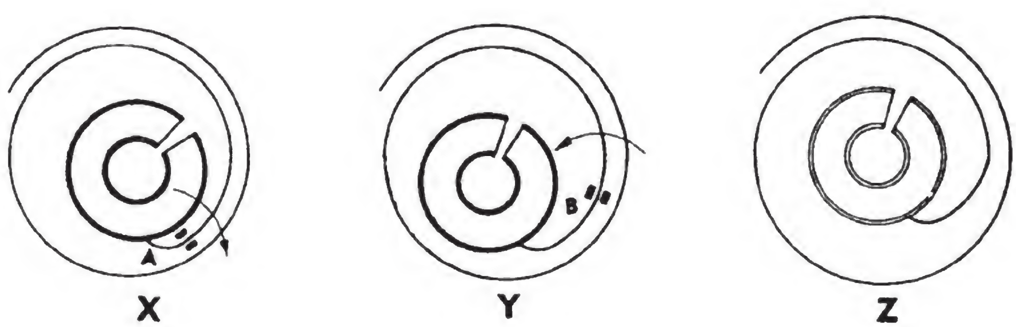

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Figure 8-13.—Correction of an error in the round (tongue inserted in too far).

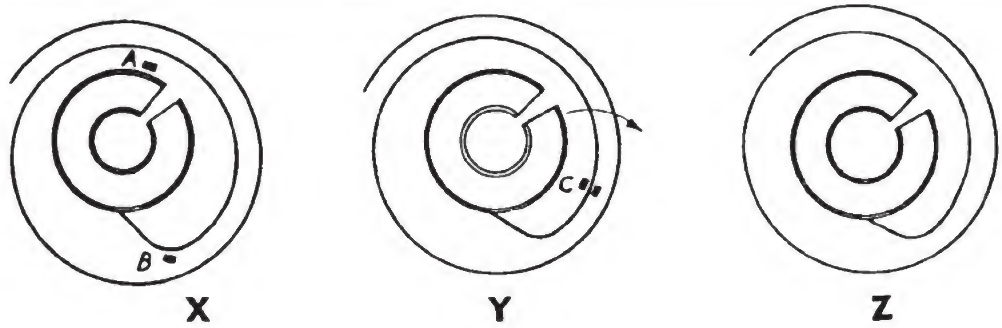

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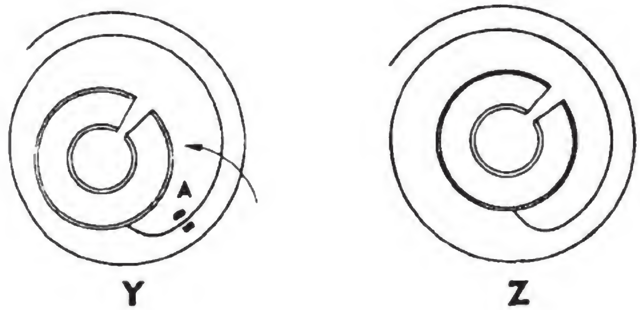
Figure 8-14.—Correction of an error in the round (tongue pinned too far out).



91.215X
Figure 8-15.—Correction of an error in the round (tongue not bent enough at elbow).

COLLET. Correction of this error is illustrated in part Z of figure 8-15. If you bend the tongue TOO MUCH at the elbow, you can make correction by grasping the inner coil at the same point as just explained and by bending it AWAY FROM THE COLLET.

At times, you may bend the tongue TOO MUCH and also pin it in TOO FAR. This is a double error you can correct by making two bends:

1. Grasp the inside coil with tweezers at point A, illustrated in part X of figure 8-16, and bend the coil AWAY FROM THE COLLET.

2. Grasp the inside coil at B (part Y, fig. 8-16) and bend the coil TOWARD THE COLLET, as indicated by the arrow. After you properly manipulate the hairspring to correct this error in the round, its position relative to the collet is as illustrated in part Z of figure 8-16.

Other errors in the round can be corrected by making bends on the inner coil next to the elbow at the CORRECT SPOTS and in the PROPER AMOUNT. With practice, you will learn how to correct all types of errors in the round. Procedures for doing the work are essentially the same for all types of hairsprings.

ERRORS IN THE FLAT

A balance wheel and hairspring are shown in figure 8-17 in the correct position in calipers for checking errors in the flat. The horizontal plane of the hairspring should be parallel with the horizontal plane of the collet.

Six major errors in the flat may be introduced into a hairspring by the colleting process, as follows:

1. The point of the tongue, represented by A in figure 8-18, may be bent downward in relation to the spiral portion of the spring. If this condition exists, all coils of the spring are HIGH opposite the pinning point.

2. The end of the tongue may be bent upward (fig. 8-18), causing all coils of the spring opposite the pinning point TO BE LOW.

3. The flat face of the tongue MAY NOT BE FIXED in a vertical position.

4. The flat face of the tongue MAY BE FIXED AT AN ANGLE.

When condition 3 or 4 exists, the spiral portion of the spring is HIGH or LOW, 90° from the pinning point.

5. The end of the tongue may be fixed TOO LOW in the pin hole of the collet, causing all coils to be HIGH opposite the pinning point.

6. The end of the tongue may be fixed TOO HIGH in the collet hole, causing all coils to be LOW opposite the pinning point.

After you true a hairspring in the flat, check it again for errors in the round. Then recheck it for errors in the flat that may have occurred while you were truing the spring in the round.

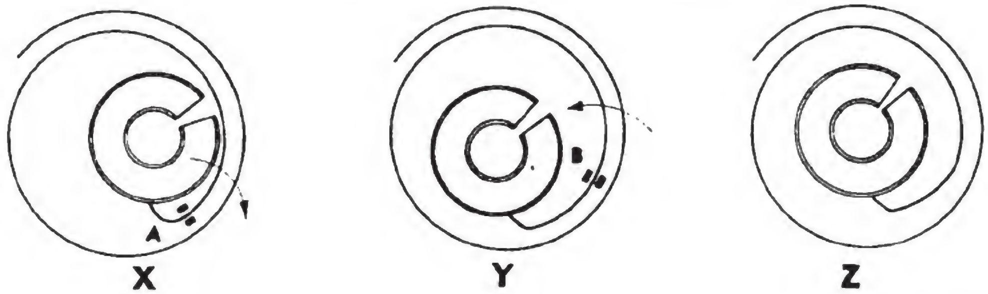


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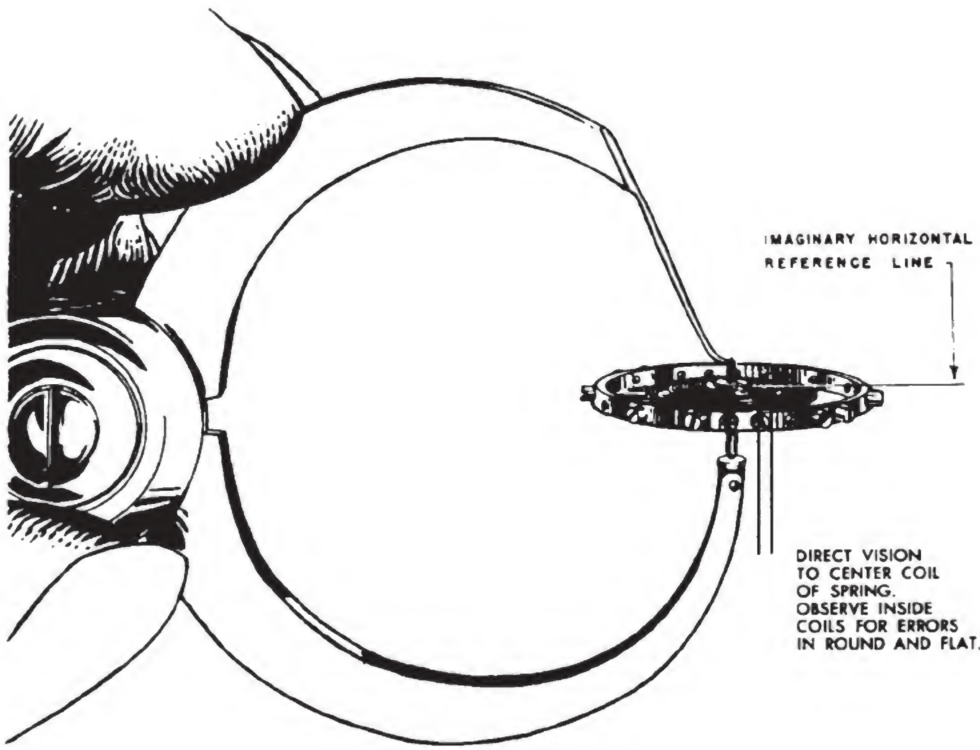
Figure 8-16. —Correction of an error in the round (tongue bent too much and pinned in too far).



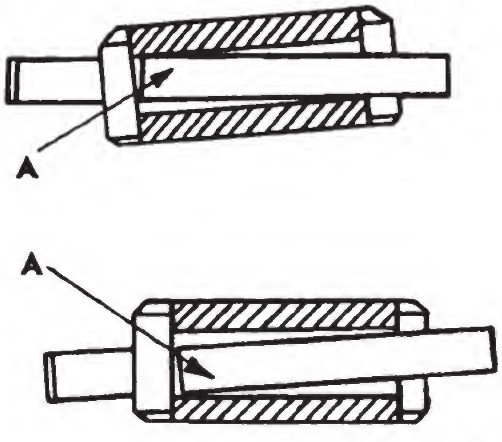
91.217X
Figure 8-17. —Checking a hairspring for errors in the round and in the flat.

In other words, check the hairspring alternately in the flat and in the round until you have it as true as you can get it in both positions.

HAIRSPRING VIBRATING

When you repair a watch or clock, you must know how to select the RIGHT hairspring for a given balance wheel. The spring must be of such length and strength that it will cause the balance wheel to vibrate a certain number of times per hour. The process for selecting a hairspring with such characteristics is called HAIRSPRING VIBRATING. The vibrating point of a hairspring IS THE POINT WHICH IS LOCATED between the regulator pins of a watch.

Before we consider the details of hairspring vibrating, it is best that we first define two words, VIBRATION and OSCILLATION. If the prongs of a tuning fork are struck on a desk and



91.218X
Figure 8-18.—Hairspring errors in the flat.

then held free, they vibrate and oscillate. When a prong of the tuning fork swings in one direction as far as the fork frame permits it to go, it VIBRATES; when the same prong returns to its starting position, it VIBRATES A SECOND TIME. A vibration, therefore, is a SINGLE SWING from one extreme limit to the other extreme limit of an oscillating body; an oscillation consists of TWO VIBRATIONS.

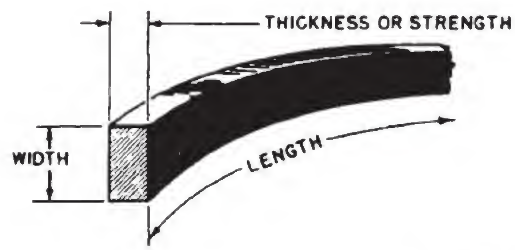
The property of a metal rod or body which causes it to vibrate is ELASTICITY. If the free end of an elastic rod (prong of tuning fork, for example) is set in motion by external force, it continues to vibrate at a constant rate until all the energy stored up in it by the force which set it in motion is expended. This quality of elasticity of a metal rod led to the development of the hairspring, so called because of its delicate nature.

The idea was conceived by watchmakers that if a fine steel rod were formed into a spiral and its outer end attached to the pillar plate of a watch and its inner end connected to the balance wheel, when set in motion, the balance wheel would vibrate a number of times per second. They learned that the number of vibrations per second was dependent upon the LENGTH and STRENGTH of the spring and the WEIGHT of the balance wheel. These three factors must therefore BE CONSIDERED when you select a hairspring for a particular balance wheel.

Now study figure 8-19, which shows a portion of a hairspring. Note all dimensions, particularly THICKNESS, which is referred to as the STRENGTH of a hairspring. The strength of hairsprings is generally indicated by a number on the box in which the manufacturer ships them. In the Swiss system, these numbers range from 18 to 96—the lower the number, the THICKER and STRONGER the spring.

All stock hairsprings of a GIVEN NUMBER, however, do NOT HAVE the same strength and, for this reason, you must use ANOTHER METHOD for determining which hairspring to use for a specific balance wheel. The method for making this determination is known as HAIRSPRING VIBRATING.

Before you vibrate a hairspring, make a preliminary check TO DETERMINE ITS SUITABILITY for the watch in which you intend to use it. This check may save you TIME and LABOR.



91.219X
Figure 8-19.—Dimensions of a hairspring.

PRELIMINARY CHECK OF A HAIRSPRING

Suppose you need a hairspring for an average watch whose balance vibrates 18,000 times per hour (300 times per minute) and you have available hairsprings whose numbers indicate they are close to what you need. How can you make a preliminary check to determine their suitability (individually) for the balance wheel in question? Proceed as follows:

1. Attach the new spring to a balance wheel.
2. With a pair of tweezers, grasp the spring a short distance from its outer end and let the balance assembly hang by its own weight, as illustrated in figure 8-20.
3. Count the spaces between the coils, downward from the point of suspension. If your count is 8 or 9, and if there are NO LESS THAN 12, and NO MORE THAN 14 whole coils between your tweezers and the pinning-in hole in the collet, the spring IS SUITABLE for the balance wheel.

The spot at which you FIRST GRASP the hairspring may not give you the correct count of whole coils between your tweezers and the

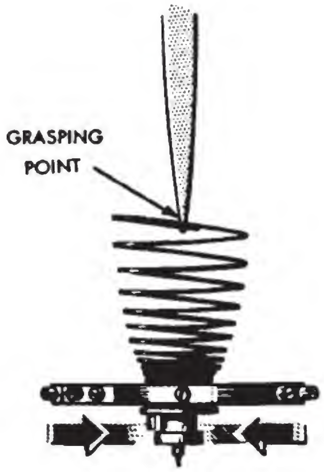


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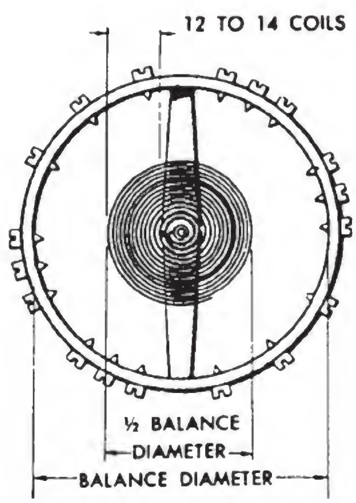
Figure 8-20.—Preliminary check of a hairspring.



91.221X
Figure 8-21.—Diameter of a correct hairspring equals the radius of the balance wheel.

pinning-in hole in the collet. When this is true, experiment with different spots until you locate the CORRECT SPOT on the hairspring which gives you the desired count. You will then find that the diameter of the spring is approximately EQUAL TO THE RADIUS OF THE BALANCE WHEEL (fig. 8-21). Observe that the hairspring illustrated has 12 to 14 coils.

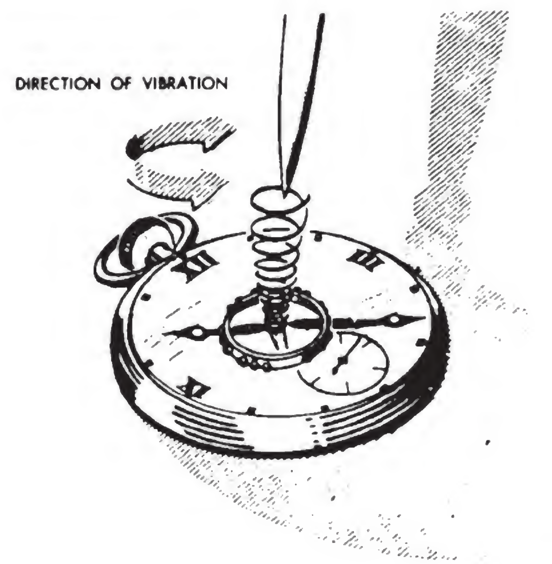
METHODS OF VIBRATING

Two different methods are generally used for vibrating hairsprings, OSCILLATION COUNTING and MASTER BALANCE. Each method is discussed in sufficient detail to enable you to understand how to use it.

Oscillation Counting Method

The procedure for selecting a hairspring for an average watch whose balance wheel oscillates 300 times per minute, using the oscillation counting method, is outlined in the following paragraphs:

1. Pick up the hairspring with tweezers at the point you located during the preliminary test, and then lower the balance assembly until the lower balance pivot touches the crystal of a watch with a second hand, as illustrated in figure 8-22.



91.222X
Figure 8-22.—Oscillation counting method of hairspring vibrating.

2. Grasp the balance wheel with the right hand and turn it counterclockwise to put the tension in the hairspring.
3. Suddenly release the balance wheel to allow the hairspring to put it into vibration. Observe the extreme position of the balance arm of the wheel and then note the position of the second hand of the watch.
4. Begin with zero and count every OTHER vibration of the balance wheel.

For a vibrating hairspring whose count is to be 18,000 vibrations per hour, the agreement (coincidence) of count with the second hand is

as follows: (Use every other vibration as a count of one.)

2.5 counts	1 second
5 counts	2 seconds
10 counts	4 seconds
25 counts	10 seconds
75 counts	30 seconds
150 counts	60 seconds

If your count shows 25 for each 10 seconds, the balance wheel and hairspring undergoing the test are vibrating 18,000 per hour, the correct number of times desired. For the sake of accuracy, however, always make your count over ONE FULL MINUTE. If the count is greater than 150 for a minute, or more than 25 for 10 seconds, the length of the hairspring is TOO SHORT. If the count is less than 150 for a full minute, or less than 25 for 10 seconds, the hairspring is TOO LONG.

The point at which you grasped the hairspring with tweezers for making your CORRECT COUNT should be located between the regulator pins of the watch. In other words, the active length of a hairspring terminates at the regulator pins, which is the POINT OF VIBRATION. Study figure 8-23. The actual length of the hairspring ends at the stud. Enough spring must therefore extend beyond the vibrating point to allow for studding (fig. 8-23).

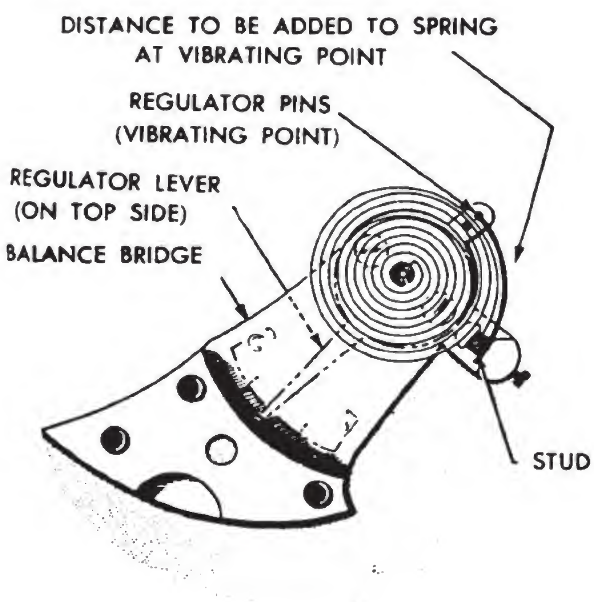


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Figure 8-23.—Vibrating point of a hairspring.

When you stud a hairspring, center the regulator on the balance bridge (fig. 8-23) and hold the spring with the tweezers at the regulator pins (vibration point). Then make a measurement on the outer coil of the spring from the vibration point toward the end of the spring, equal to the distance from the regulator pins to the stud, plus enough spring to go through the stud (fig. 8-23). Allow just a bit of the outer coil to extend through the stud and break it off at this point.

Master Balance Method

The way to find the vibrating point of a hairspring by the master balance method is to compare the rate of oscillation of the balance wheel and hairspring with that of a master balance, shown in figure 8-24.

A master balance is a tool with a master balance wheel and hairspring enclosed in a glass covered case for protection. The balance wheel is accurately adjusted to vibrate 18,000 times per hour. It has a pair of tweezers secured to the end of an adjustable horizontal arm that extends over the face of the balance for holding a balance wheel undergoing a test. By means of adjustment screws, you can move the tweezers up and down, or out or in from the upright rod which holds the horizontal arm. The tweezers have a plunger for opening and closing the jaws. The balance also has a starting lever for starting the balance wheels in motion, and a stop button for stopping them from vibrating.

The procedure for locating the vibrating point of a hairspring with a master balance follows:

1. Place the outer coil of the hairspring between the tweezer jaws, as illustrated in figure 8-24.

2. Unscrew the lower adjustment knob and lower the tweezers enough to bring the lower pivot of the test balance wheel into contact with the glass cover above the master balance wheel. Contact with the glass cover over the master balance steadies the test balance while it vibrates and makes observation easier.

3. Adjust the arms of the test balance wheel by turning the master balance tweezers in their friction support.

4. Start the master balance by depressing and releasing the starting lever, which gives the starting impulse to the master and test balance wheels simultaneously.

5. Watch the arms of both balance wheels as they vibrate. If they are in exact synchronization with each other, the tweezers are holding

91.224X
Figure 8-24.—Vibration counting with a master balance.

the test hairspring at the EXACT POINT OF VIBRATION. If one balance wheel begins to move out ahead of the other, THAT WHEEL IS THE FASTER.

6. If the test balance wheel steps out of synchronization first, the active length of its spring is TOO SHORT. Depress the stop button of the master balance and reset the tweezers so as to increase the active length of the test hairspring. Re-start the master balance and observe the arms of the two balance wheels. Continue increasing or decreasing the active length of the test hairspring until you have the balance wheels in perfect synchronization.

After you find the vibrating point of a hairspring, you can then proceed with the studding operation, described under the OSCILLATION COUNTING method of hairspring vibrating.

OVERCOILING

Overcoiling is the process of forming the outer coil of a hairspring in a manner that will ensure the following conditions when the hairspring is operating in a watch:

1. The center of gravity of the spring consistently COINCIDES with the axis of the balance staff.

2. As the spring winds and unwinds, its coils remain concentric with the axis of the balance staff, and its elastic force increases and decreases in proportion to the angle of rotation of the balance wheel from the line of centers.

3. The spring DOES NOT CAUSE the balance pivots at any point in their angular movement to exert a side thrust or pressure against their jeweled bearings.

4. The balance unit makes each swing (vibration) in the SAME AMOUNT OF TIME regardless of the size of the arc an impulse causes it to make while travelling.

A balance unit which operates in the manner just described is called an ISOCHONAL BALANCE UNIT; that is, the torque on the balance staff is always directly proportional to the angle through which the balance turns.

A flat hairspring has a characteristic that causes its coils to bunch together first on one side of the balance staff and then on the other as it vibrates. Because of this action, a side thrust (pressure) is created between the balance pivots and their jeweled bearings.

As a flat hairspring is wound, the pressure (side thrust) is exerted in a direction AWAY from the regulator pins. See part A of figure 8-25. As the spring unwinds, the side thrust is exerted TOWARD the regulator pins (part B, fig. 8-25). This pressure causes an unequal turning action (torque) on the balance staff—the greater the swing of the balance, the greater the side thrust and resulting friction.

This torque means that energy received by the roller jewel from the pallet does not ALL GO into winding and unwinding the hairspring—some of it is dissipated in overcoming friction. Because of this, the force exerted on the balance staff by the hairspring is NOT DIRECTLY PROPORTIONAL to an angle through which the balance staff turns. A watch with such a hairspring GAINS in the high arcs and LOSES in the low arcs of motion. In other words, it is NOT an isochronal hairspring.

In order to overcome the lack of uniformity in rate of a flat hairspring, watchmakers knew they would have to alter the shape of the hairspring in a manner that would ensure uniformity of rate in HIGH and LOW arcs of motion. As a result of their ideas and experiments, a new type of hairspring was developed.

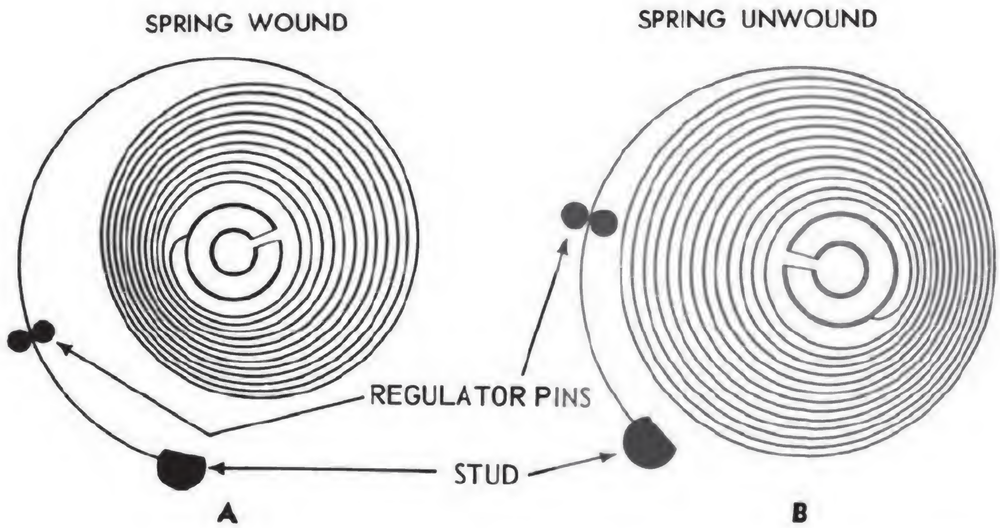

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Figure 8-25.—Characteristics of wound and unwound flat hairsprings.

BREGUET (OVERCOIL) HAIRSPRING

A Swiss horologist, Louis Breguet, conceived the idea that if the outer coil of a flat hairspring were bent up and laid over the top of the main body of the spring the spring would wind and unwind concentrically—it would be free of side thrust, and the force on the balance would be proportional to the angle through which it turned.

At first, Breguet made two bends (up to get the rise, then down to get the coil in a horizontal plane) in the outer coil of a hairspring opposite the mouth of the collet and brought the coil straight across the hairspring to the stud. This type of overcoil, however, produced an error opposite the one produced by a flat hairspring—a faster rate in the low arcs of motion than in the high arc. Breguet therefore decided that between the two extremes there must be a place to lay the overcoil which would cause the balance wheel to make its vibration in the same time, regardless of whether it swung in a high or low arc of motion. Because he DID FIND the correct place to lay the overcoil on a hairspring to give it isochronal qualities, the overcoil hairspring is frequently called the BREGUET HAIRSPRING.

Three basic types of overcoils in hairsprings are in common use today. See figure 8-26. When you select one of these overcoils for use on a hairspring, take into consideration the location of THAT PORTION of the overcoil represented by AB in figure 8-26 in relation to the balance staff. If line AB is located too close to the balance staff, the watch will GAIN in the low arcs and lose in the high arcs of motion. If AB is located TOO FAR FROM the balance staff, the watch will have a losing rate in the low arcs and a gaining rate in the high arcs.

OVERCOILING PROCEDURE

In making an overcoil on a hairspring, avoid weakening or damaging the spring by A SHARP BEND. It is best for you to practice making bends on an old hairspring until you learn the technique for making them correctly.

Two types of tweezers are used in making overcoils, as shown in figure 8-27. Regular overcoiling tweezers have ends made in various widths for different sizes of springs. The inside of one leg is convex; the opposite leg is concave, which means that when closed the legs fit closely together. Knee-bend overcoiling tweezers are good for making a variety of adjustments on springs of different sizes. Study the enlarged portion of the tweezer points in figure 8-27. To prepare these tweezers for use, make two adjustments: (1) adjust the width of the slot in the tweezers by the slide and small setscrew A; and (2) regulate the distance apart the tweezer points should be when closed by setscrew B.

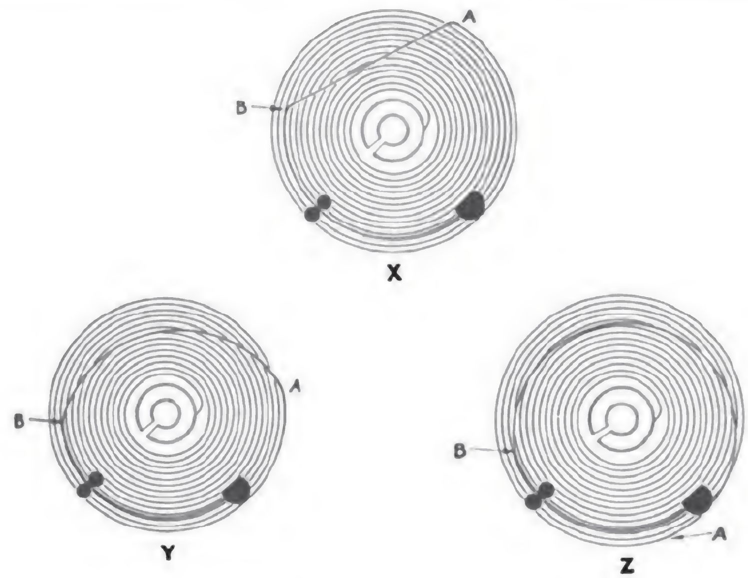

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Figure 8-26. —Three basic types of hairspring overcoils.

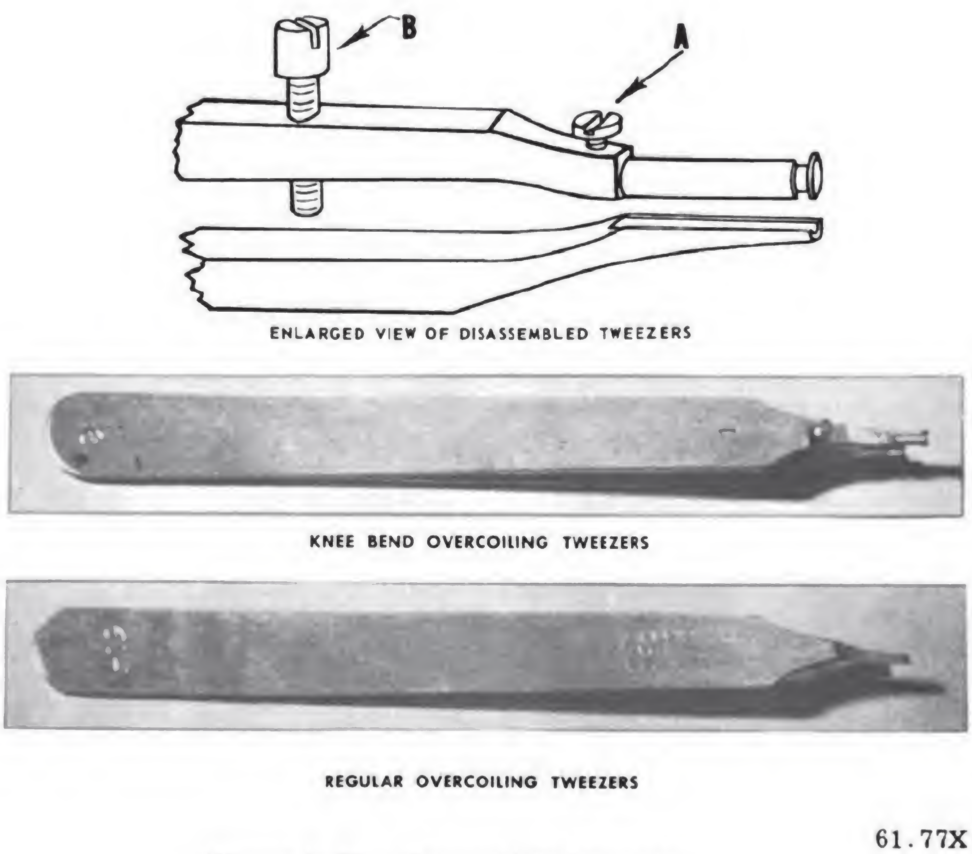

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Figure 8-27. —Overcoiling tweezers.

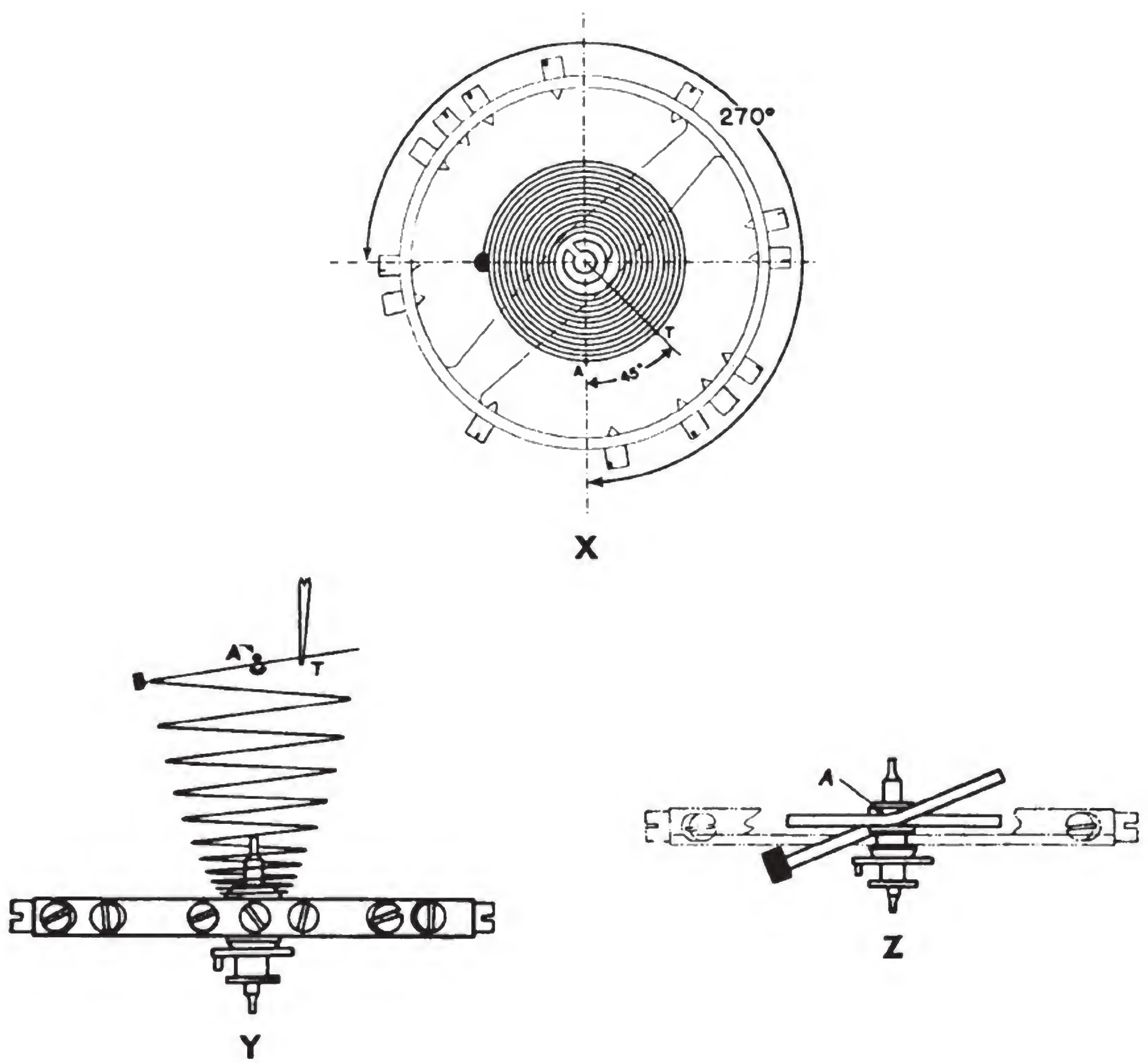

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Figure 8-28.—Making the first bend of an overcoil.

The last adjustment determines the angle of rise of the overcoil from the main body of the spring. With practice in making bends on a discarded hairspring, you will soon learn how to adjust and use overcoiling tweezers.

Suppose you need to put an overcoil on a hairspring like the one illustrated by B in figure 8-26. What procedure would you follow to make this overcoil? The discussion in the next paragraphs explains the procedure.

The First Bend

Start the first bend of the overcoil at point A, about 270° from the stud (part X, fig. 8-28).

NOTE: This angular measurement varies with different sizes and types of balance units. Suspend the spring with a pair of ordinary tweezers and allow the balance wheel to hang by its own weight, as shown at T (about 45° to the right of A) in part Y of figure 8-28. Then insert the hairspring in the slotted end of the knee-bend tweezers (concave part below slotted part) and apply pressure to put as much bend in the coil as setscrew B in the tweezers allows. When you remove the tweezers from the coil, your bend should look like the one illustrated by A in part Z of figure 8-28. This is about a 25° rise from the main body of the spring.

The Second Bend

The second bend in the coil is located at B (parts X, Y, and Z of fig. 8-29). The purpose of this bend is to bring the overcoil into a plane parallel with the main body of the spring. The location of point B is determined by the height desired for the overcoil above the spring. This bend is usually 2 1/2 times the width of the spring (part Z, fig. 8-29). To make the bend, use two steps: (1) grasp the coil with ordinary tweezers at T, about 45° from point B; and (2) apply the knee-bend tweezers at B (concave part above slotted part) and press them together as much as possible. When the bend is completed, the hairspring will have the appearance of the one shown in part Z of figure 8-29.

After you make the bend of the overcoil at B, you will find that the overcoil is not exactly parallel with the main body of the spring—a point 180° from B is TOO LOW. To make the overcoil parallel with the rest of the spring, grasp it a little to the left of bend B with a pair of ordinary tweezers held upright in the left hand and bend the overcoil toward you with another pair of tweezers placed upright on the overcoil slightly to the right of B.

The Third Bend

Make the third bend in the overcoil at point C (fig. 8-30). Use a pair of regular overcoiling tweezers to effect this bend, about 45° from bend A. Execute the bend by grasping the overcoil at point C with the convex leg of the tweezers

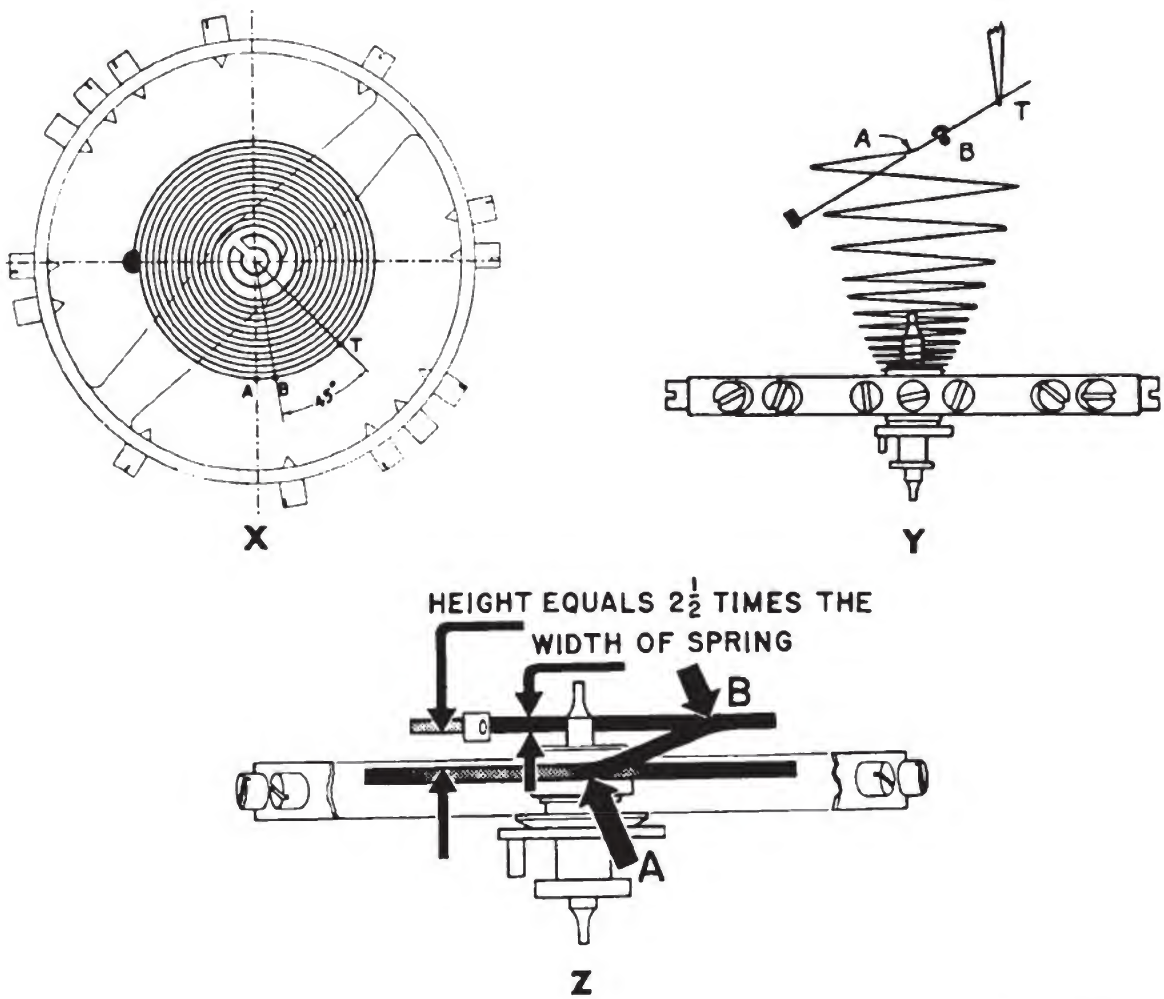

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Figure 8-29.—Forming the second bend of an overcoil.

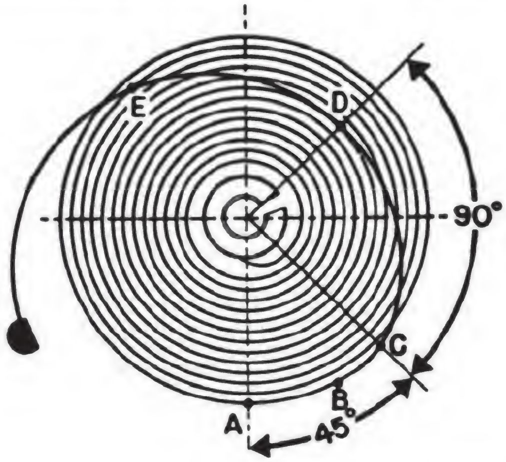

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Figure 8-30.—The third bend of an overcoil.

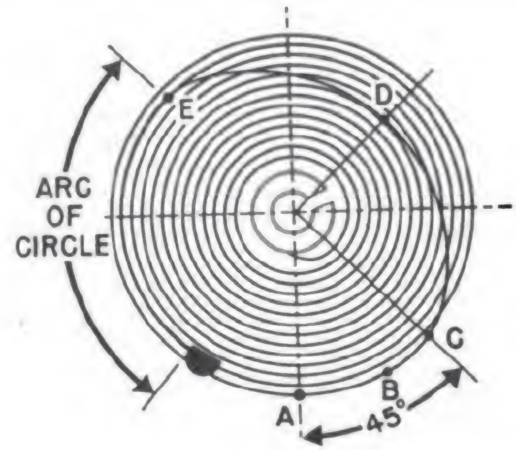

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Figure 8-31.—Making the fourth bend of an overcoil.

nearest the balance staff and by squeezing the tweezers until you have the overcoil at point D nearly halfway between the outer coil and the collet.

The Fourth Bend

The fourth bend of the overcoil goes at point E (fig. 8-30). To get the correct position for this bend, measure the distance from the hole jewel in the balance bridge to the regulator pins. This bend is the regulator circle (arc) in the outer coil, and it is the final step in overcoiling. The regulator pins are mechanically held at a fixed distance from the hole jewel and move in an arc of a circle. For this reason, the part of the overcoil that lies in the path of the regulator pins must be a perfect arc of a circle and be free of small kinks; otherwise, proper regulation of the watch will be impossible.

You can form the regulator circle in the outer coil of a hairspring in two ways: (1) grasp the overcoil with tweezers (perpendicular to the spring) at E and, through proper application of pressure, form an arc which looks like the one from E to the stud in figure 8-31; and (2) grasp and push on the outside of the coil with another pair of tweezers until you form an arc between E and the point where you applied the pressure. CAUTION: If you apply pressure TOO CLOSE to point E, you will make a kink in the coil. Continue in this manner to form a second portion of the regulator circle, and then continue as necessary until you finish the arc.

Gradual Bend Method of Overcoiling

Another method for bending the outer coil of a hairspring in order to form an overcoil is used to such an extent that it warrants explanation. It is known as the GRADUAL BEND METHOD. The procedure for forming an overcoil by this method follows.

First, make the initial bend at A (part X, fig. 8-32), about 350° from the stud. NOTE: This measurement varies in accordance with requirements for different balance units. Grasp the unstaked hairspring at A with a pair of ordinary tweezers held vertically against the bench surface with the left hand. With another pair of tweezers, held vertically in the right hand, grasp the coil about one millimeter to the right of the other tweezers. Hold the tweezers in the left hand still and tilt the tweezers in the right hand toward your body. This movement bends the spring in such manner that point B, 180° away, is the highest point. Then put another bend in the spring at A in order to raise point B UP 2 1/2 times the width of the spring.

Next, turn the spring clockwise until point B is near you, and grasp it at this point with a pair of tweezers held in the right hand and against the bench surface. About one millimeter to the left, grasp the spring with the other pair of tweezers held in the left hand. NOTE: Keep inner surfaces of the tweezers in the same plane as that of the portion of the hairspring to be bent. Hold the left hand steady and tilt the tweezers in the right hand until the top comes

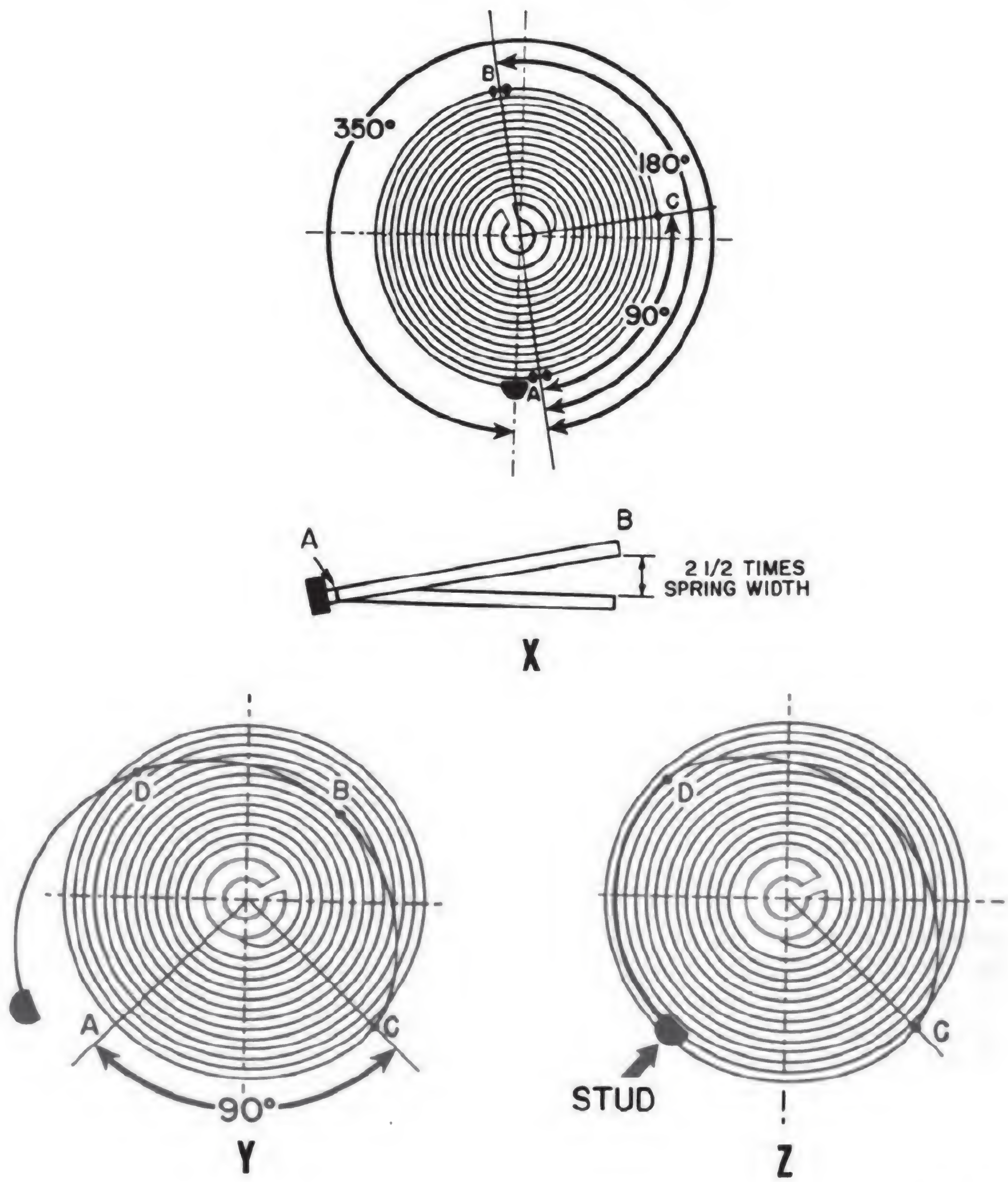

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Figure 8-32.—The gradual bend method for forming an overcoil.

toward you. This manipulation bends the part of the overcoil between B and the stud upward. Put enough bend in the overcoil at B to bring it into a plane parallel to the main body of the spring.

With regular overcoiling tweezers, make the FIRST INWARD BEND at point C, 90° from point A. Exert enough pressure on the tweezers to move point B almost halfway between the collet and the outer coil (part Y, fig. 8-32). Using the same tweezers, make the next bend at D, where the overcoil crosses over the second coil.

Use either of the overcoiling methods just described to form the regulator circle from point D to the stud. Make a knee-bend overcoil. Part Z of figure 8-32 shows how the completed overcoil and spring look.

FINISHING PROCEDURE

When you form an overcoil on a hairspring in the correct manner (parallel with the main body of the spring, properly circled, centered), and with the regulator pins correctly located, no

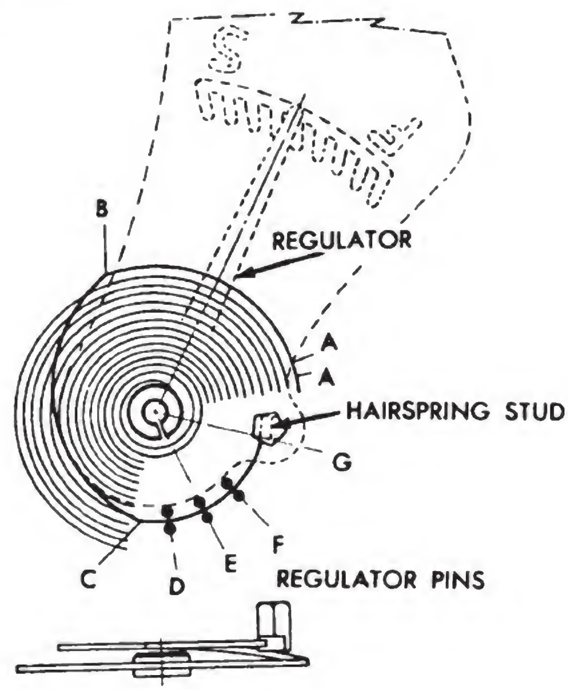

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Figure 8-33.—Overcoil circled between regulator pins.

finishing touches are required. The only remaining thing to do is to put the balance unit in the watch.

If an overcoil does not have the characteristics listed in the previous paragraph, one of the following conditions is probably causing the imperfection:

1. The height of the overcoil above the main body of the spring is INCORRECT.
2. The overcoil is NOT PARALLEL to the hairspring body.
3. The distance of points, C, D, E, F, and G from the balance staff ARE NOT UNIFORM (fig. 8-33)
4. The hairspring stud IS NOT PLACED at a proper angle to the hairspring.
5. The hairspring IS BENT at the entrance to the stud (G in fig. 8-33).
6. The distance from the balance staff to the center line of the regulator pins IS NOT UNIFORM.

You can correct the first three conditions by bending and reforming the overcoil. Center the stud on a line passing through it and the center of the collet.

If you bent the overcoil TOO FAR TOWARD the balance staff when you secured it to the study, it will strike against the inner regulator pin and throw the remainder of the overcoil out of position. Move the regulator to the SLOW side of the balance cock (point F). Then move from SLOW to FAST (from F to D). If the overcoil moves AWAY from the balance staff as you move the regulator pins from F to D, the end section of the overcoil is not properly circled and must be corrected, as follows:

1. Move the regulator pins as close as possible to the stud and bend the overcoil OUT and AWAY from the balance.
2. Move the regulator pins from SLOW to FAST and observe the action of the overcoil. If it remains MOTIONLESS, your bend in the overcoil was sufficient to make proper correction.

If when securing the overcoil to the stud you bent it TOO FAR AWAY from the balance staff, it will strike against the outer regulator pin and throw the rest of the coil TOO FAR OUT from the balance staff. Move the regulator pins from SLOW TO FAST and observe the action of the overcoil. If it moves TOWARD the balance staff, make necessary corrections (with regulator pins straight) by bending the overcoil TOWARD the balance staff. With a strong loupe, check this part of the overcoil by moving the regulator pins slowly to their different positions, with the balance wheel stopped and the roller jewel in the fork slot.

CHAPTER 9

CLOCKS

In this chapter we discuss the mechanisms of clocks used on Navy ships and stations, the tools used in clock repair, and the procedures for maintaining and repairing clocks. Because of their wide use throughout the Navy, it is essential that you understand how to repair these clocks. Besides, before you can qualify for advancement to Instrumentman 1, you must know the procedure for disassembling, cleaning, lubricating, and reassembling clock main and time trains; and in order to qualify for an Instrumentman C, you must know how to replace clock bushings, flat springs, wheels, pallet stones, clock escapements, and so on. In addition, you must know how to replace a clock balance staff, and be able to true and poise a clock balance wheel.

MECHANISMS AND PARTS

Chelsea and Seth Thomas boat, deck, and mechanical clocks are constructed in accordance with Navy specifications, to fulfill all the Navy's requirements for timepieces of this type. Basically, they consist of an eight-day movement enclosed in a metal or black phenolic case, which is dust- and moisture-proof and has a cushioned bulkhead mounting plate. These clocks (mechanical excluded) have a lusterless black 12-hour dial with luminous hands and dots next to the numerals, and some are equipped with sweep second hands.

Boat and deck clocks are wound, set, and regulated through a dust-proof cover in the back of the case; and they have 3 1/2 or 6-inch dials and weigh 4 1/4 or 7 pounds, respectively. Mechanical clocks are wound and regulated through the dial, and are used for general purposes, where boat and deck clocks are not required. They have 6 or 8 1/2-inch dials and weigh 3 or 5 pounds, respectively.

PLATES AND BRIDGES

The foundation of clock movements is the front plate, illustrated in figure 9-1. Other plates and bridges which support moving parts are fastened to the front plate by pillars. Note the height of the back plate pillars, as compared to the height of the train plate pillars and the fourth upper bridge pillars.

As shown in figure 9-1, some clock movements have three plates and one bridge; but some movements do not have a fourth upper bridge. Those with eccentric second hands have the upper pivots for the intermediate, center, third, and fourth wheels included in the train plate, which also has provisions for mounting the escapement. The train plate contains pivot holes for the intermediate and center wheels, and the back plate contains the upper pivot hole for the mainspring barrel.

Movements with sweep second hands have the upper pivot holes of the third and fourth wheels in the fourth upper bridge. The starting knob and setting shaft of some clocks are mounted on the back plate, as are four pillars to which the dust cover is secured.

Now study figure 9-2, and compare it with the clock movement illustrated in figure 9-1. Note in these illustrations that the perpendicular broken lines indicate where screws and parts fit in the whole mechanism.

POWER ASSEMBLY

The power assemblies of two different types of clocks are shown in figure 9-3. Like conventional watch and clock movements, the mainspring is contained in a barrel. Observe the hook on the barrel arbor to which the inner end of the spring is attached, and also the hook on the inside of the barrel to which the outer end is secured. The barrel arbor in part A of figure

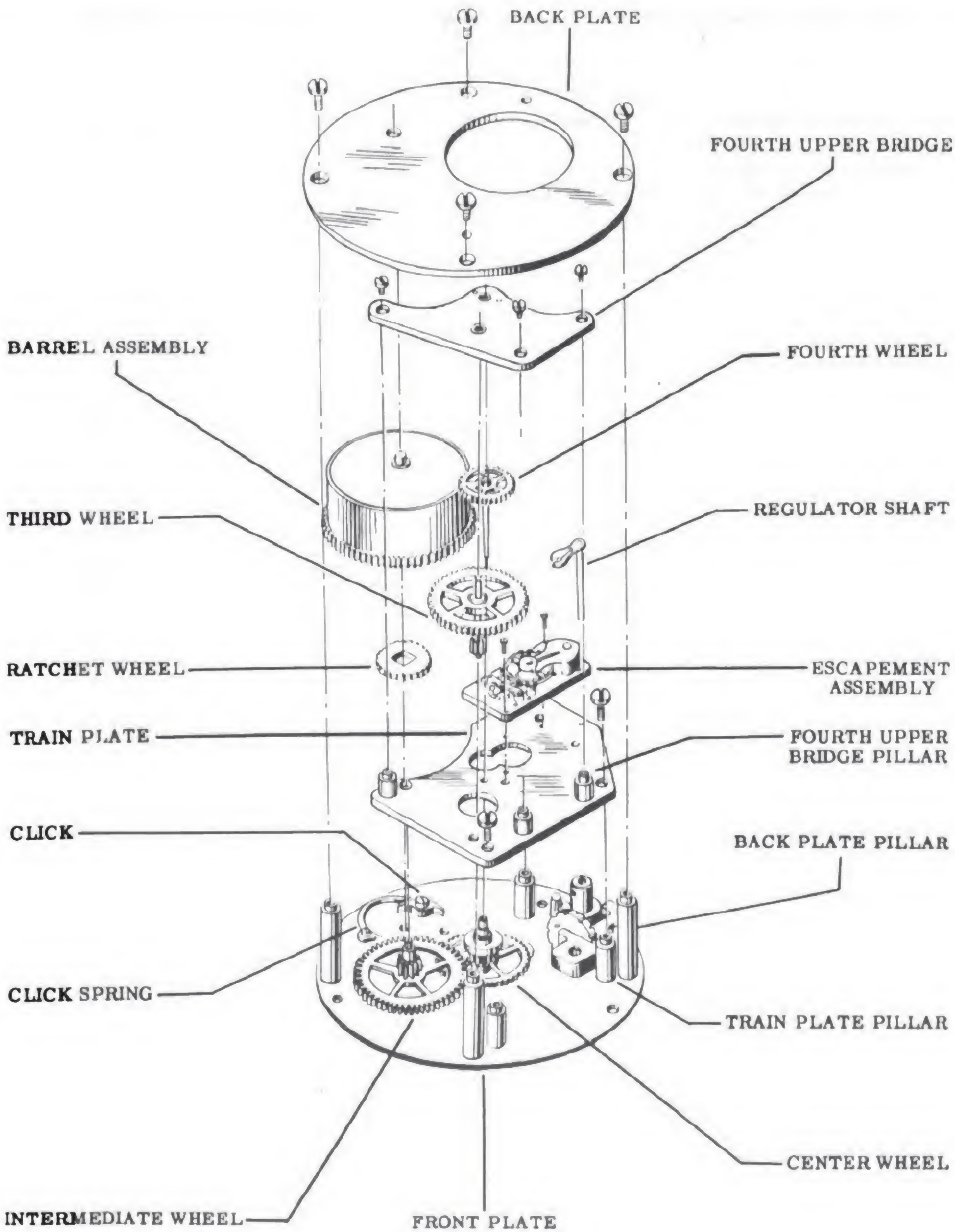

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Figure 9-1 —Chelsea mechanical clock movement.

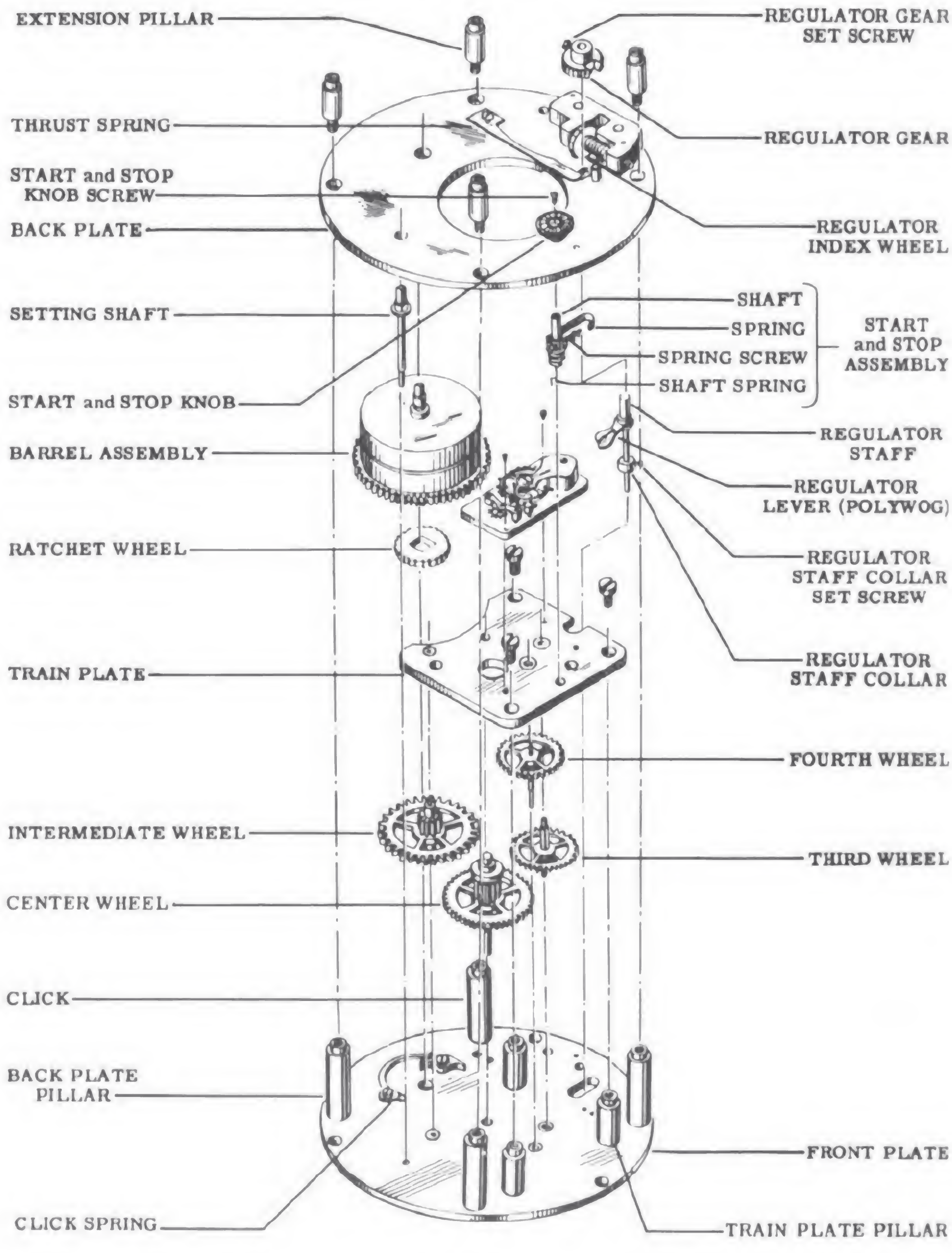

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Figure 9-2. –Chelsea boat and deck clock movement.

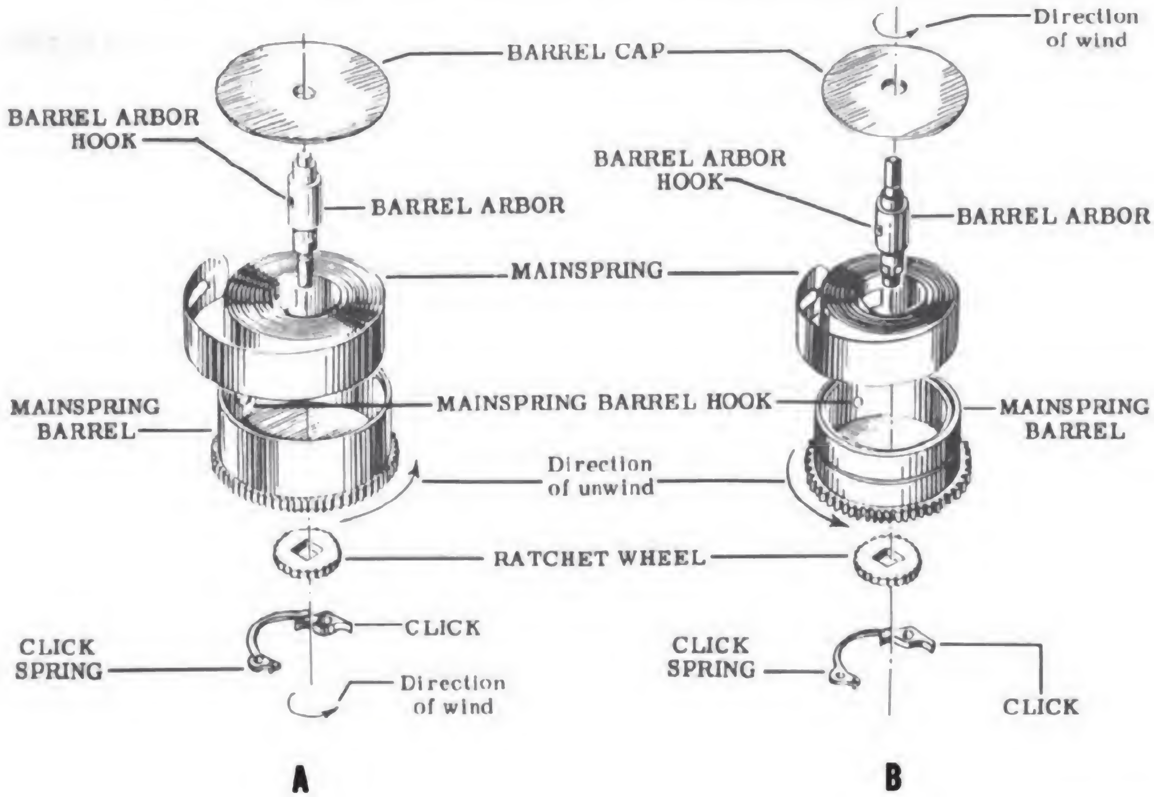


Figure 9-3.—Clock power assemblies.

9-3 is so positioned that the mainspring can be wound through the dial attached to the front plate. In the movement shown in part B of figure 9-3, the ends of the barrel arbor are reversed.

The key for winding the mainspring fits on the squared end of the barrel arbor. As the spring is wound, a click (held in place by a spring) engages and locks the teeth of a ratchet wheel mounted on the barrel arbor just behind the front plate. The click allows the barrel arbor to turn in a clockwise direction ONLY.

As you can see from the above explanation, the power assembly of these clocks is so designed that the mainspring can unwind ONLY by turning the barrel, which is geared to the main train of the clock.

THE MAIN TRAIN

Turn now to figure 9-4 and study the main train of one clock mechanism, and then compare it with the main train of another type of clock mechanism illustrated in figure 9-5.

The main train consists of the teeth on the mainspring barrel and the intermediate, center, third, and fourth wheels. Power from the mainspring is delivered to the escapement through the wheels in the order mentioned. Note that the teeth on the edge of the barrel constitute the first wheel in the train, as was true of the watch main train you studied in chapter 7; but the wheel driven by the barrel is called the INTERMEDIATE wheel. Some clock manufacturers call this wheel the SECOND wheel.

The center wheel has a long arbor which projects through the front plate and mounts a cannon pinion, as illustrated. Observe that the position of the wheels is different in the two mechanisms. The reason for this is that the movement in figure 9-5 has an eccentric second hand which fits on the arbor of the fourth wheel. The setting pinion of this mechanism meshes with the minute wheel. The sweep second hand in the mechanism shown in figure 9-4 is also secured to the arbor of the fourth wheel, but note how it extends up through the arbor of the center wheel.

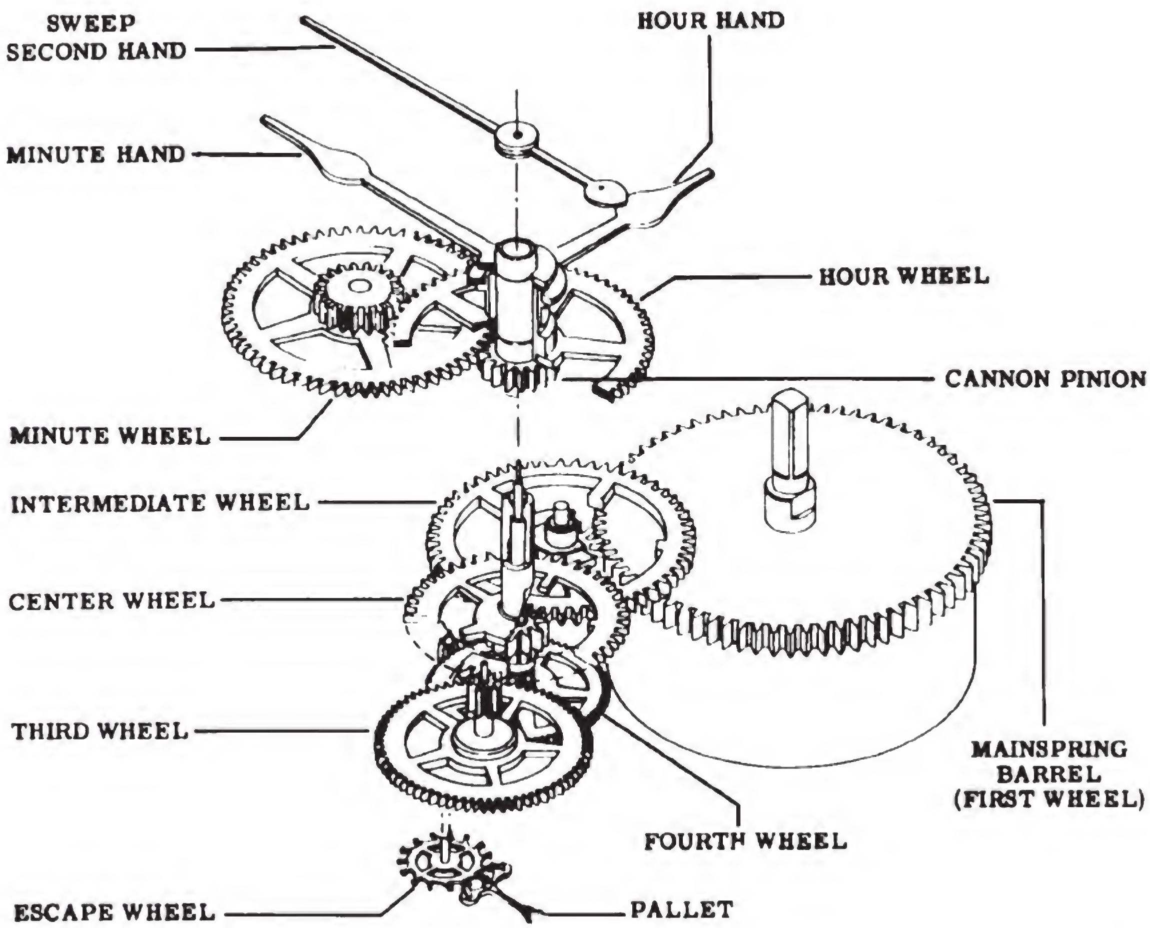


Figure 9-4. —Mechanical clock train.

Study the pinions and arbors of the different wheels of the main train in illustration 9-4. Observe the hollow arbor of the cannon pinion, the center wheel assembly, and the long arbor on the fourth wheel. The minute hand is attached to the end of the cannon pinion, and the cannon pinion drives a minute wheel which drives an hour wheel, freely riding around the shaft of the cannon pinion. As you learned previously, the cannon pinion, the minute wheel, and the hour wheel constitute the DIAL TRAIN.

THE ESCAPEMENT

A clock escapement is shown in figure 9-6. The parts of this escapement are: (1) the escape wheel, to which power is transmitted from the mainspring through the fourth wheel of the main train; (2) pallet and escape bridges; (3) the pallet; (4) the balance wheel assembly; (5) the balance cock; and (6) an escapement plate, which forms the foundation for the entire escapement. It also contains the lower jewel bearings for the escape wheel, the pallet, and the balance wheel assembly. The balance cock contains the upper jewel bearings of the balance wheel assembly.

As you learned earlier in this chapter, the escapement controls the unwinding of the mainspring in such a manner that the second, minute, and hour hands travel around the dial at proper speed. Each tooth of the escape wheel passes one of the locking jewels of the pallet at regulated intervals. As each escape tooth goes by, it delivers an impulse to a pallet jewel which transmits the impulse to the balance wheel. The back-and-forth motion of the balance wheel

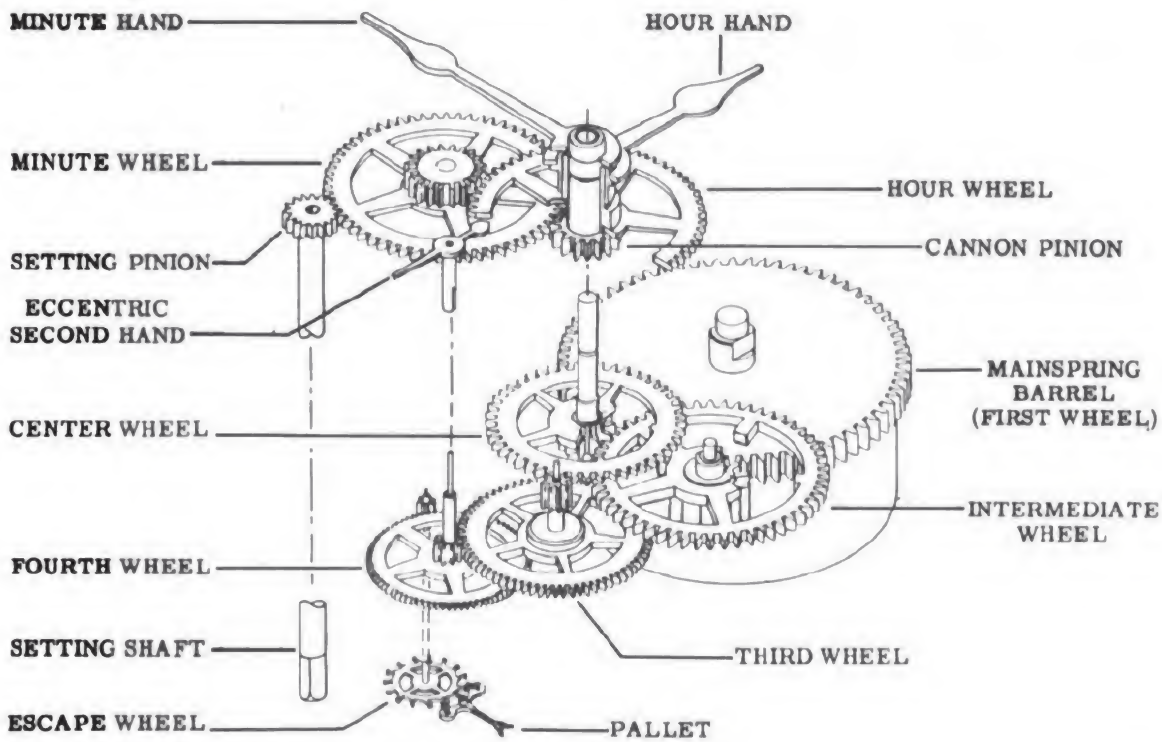


Figure 9-5.—Boat and deck clock train.

moves the pallet back and forth, thereby regulating the speed of release of the escape wheel teeth. The impulse from the pallet drives the balance wheel in one direction and then in another, the rotation being controlled by the hairspring. The roller jewel receives the impulse from the pallet fork to drive the balance wheel, and the roller jewel also strikes the pallet fork to release each escape tooth.

CLOCK JEWELS

Navy mechanical, boat and deck clocks generally have eleven jewels: (1) one hole jewel and one cap jewel at each end of the balance staff, (2) one hole jewel at each end of the escape wheel and pallet staffs, (3) a balance roller jewel, and (4) two pallet jewels (stones). These jewels are at the points which receive the most wear; and they provide smooth operation, prolong the wear of parts, and give accurate timekeeping.

MAINTENANCE AND REPAIR

This section tells you how to disassemble a clock mechanism, how to disassemble an escapement, how to clean various parts, how to inspect parts for defects or breakage, how to make repairs, and how to reassemble and oil parts. The manipulation of hairsprings was already discussed in chapter 8 of this text, and clock adjustments are discussed in chapter 10. Chapter 11 gives the procedure for making watch and clock parts. You already learned how to stake a balance wheel (same for watches and clocks), and also how to true a balance wheel in the round and in the flat.

CLOCK REPAIR TOOLS

Special tools are required for repairing clocks, as you can see by studying those shown in figure 9-7. The names of the tools and uses (stated or implied) are given. Note particularly the sizes and shapes of these tools, which were specially designed for use on clock parts. When you repair clocks, you need to know which tool to use for a specific purpose (job). For example, if you are going to work on a Chelsea escapement, you need an escapement block designed for that particular escapement, not one

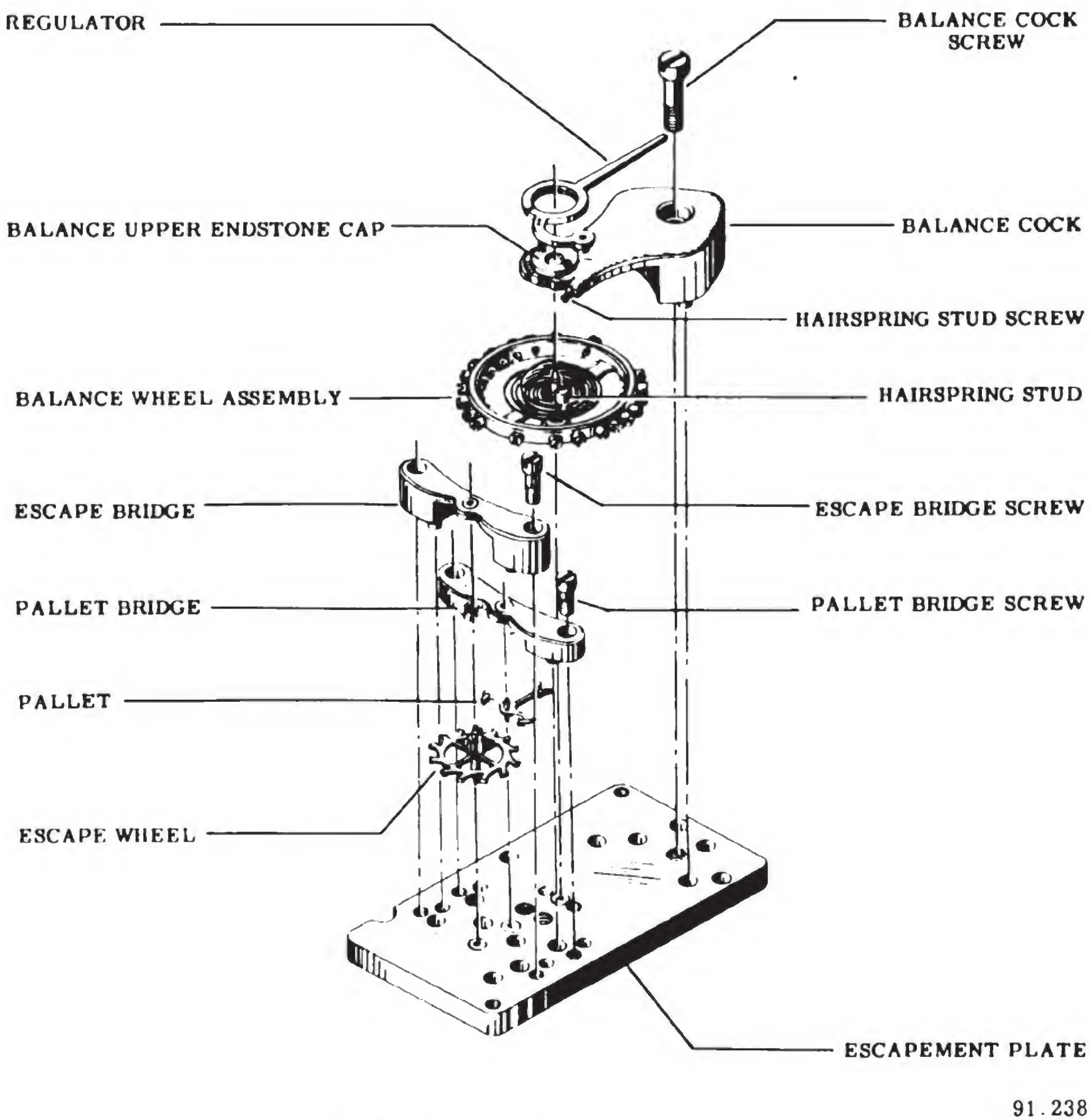


Figure 9-6.—Clock escapement.

designed for a Seth Thomas or an Elgin escapement.

DISASSEMBLY

The purpose of disassembly is to break down the clock movement to the extent required for proper inspection and cleaning, and repairing as necessary. If the movement is not broken down in accordance with recommended procedure, incomplete inspection and improper cleaning result. On the other hand, if you break down the movement to a greater extent than necessary, you make extra work for yourself. For these reasons, proper disassembly is an important part of clock repair.

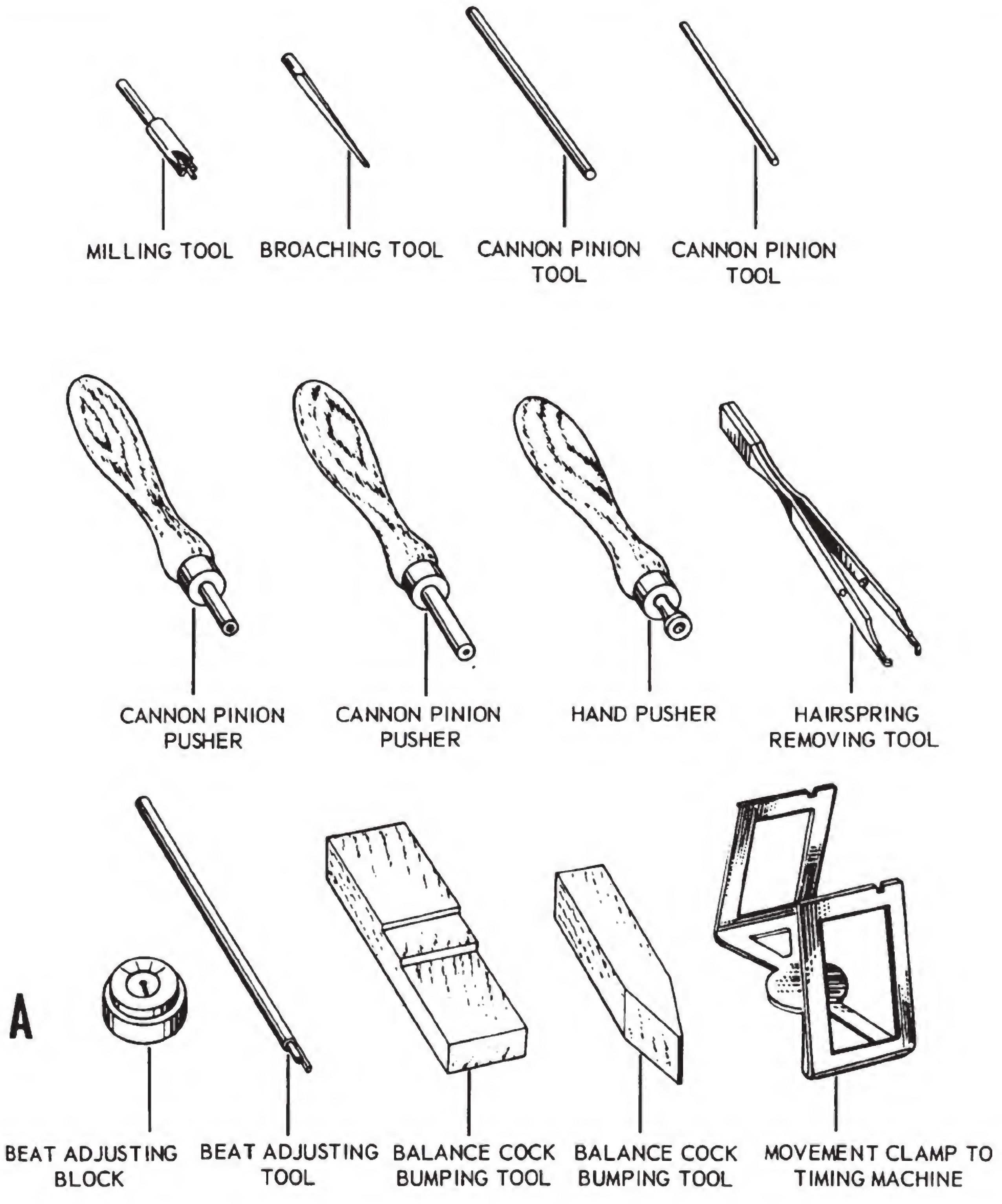
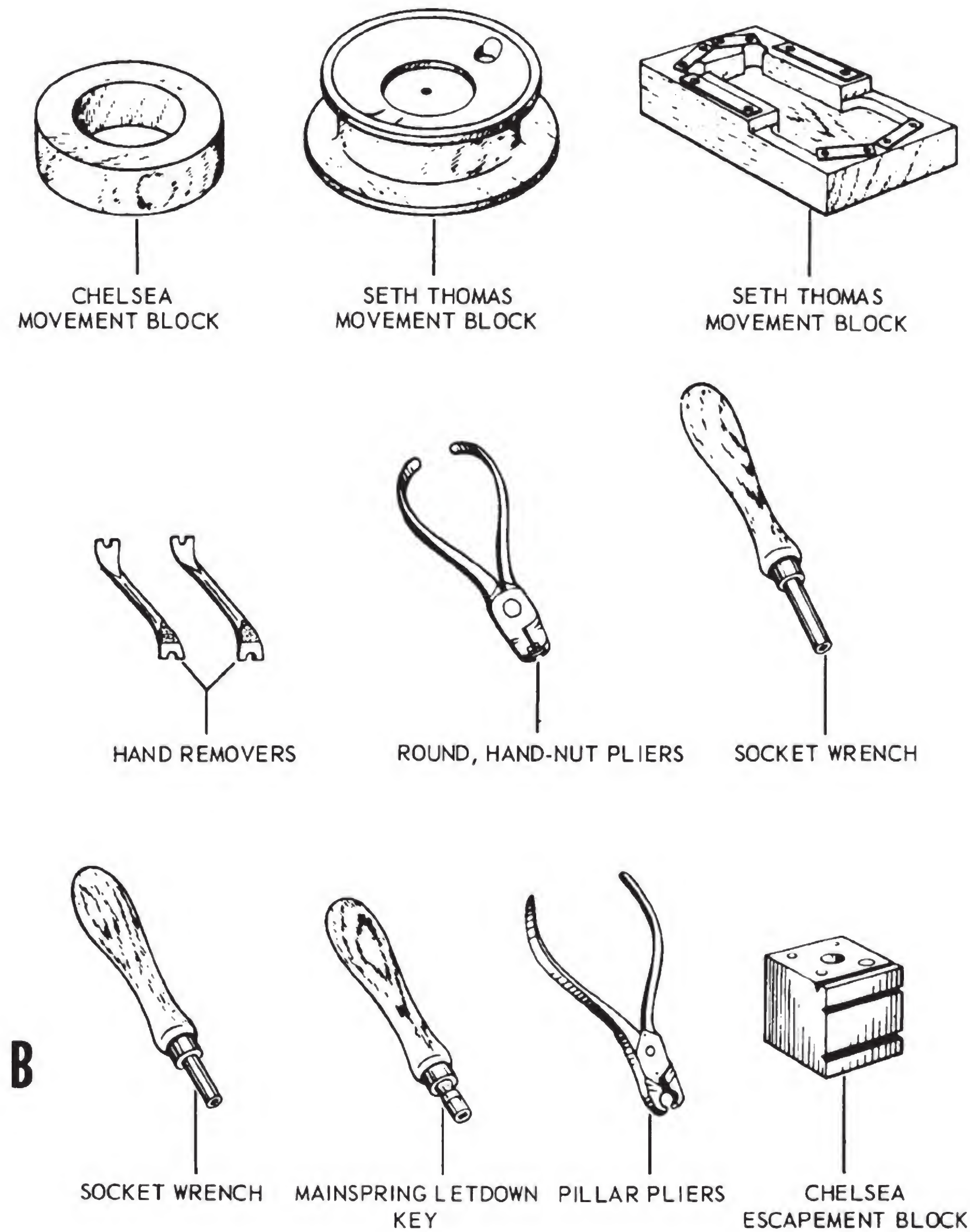
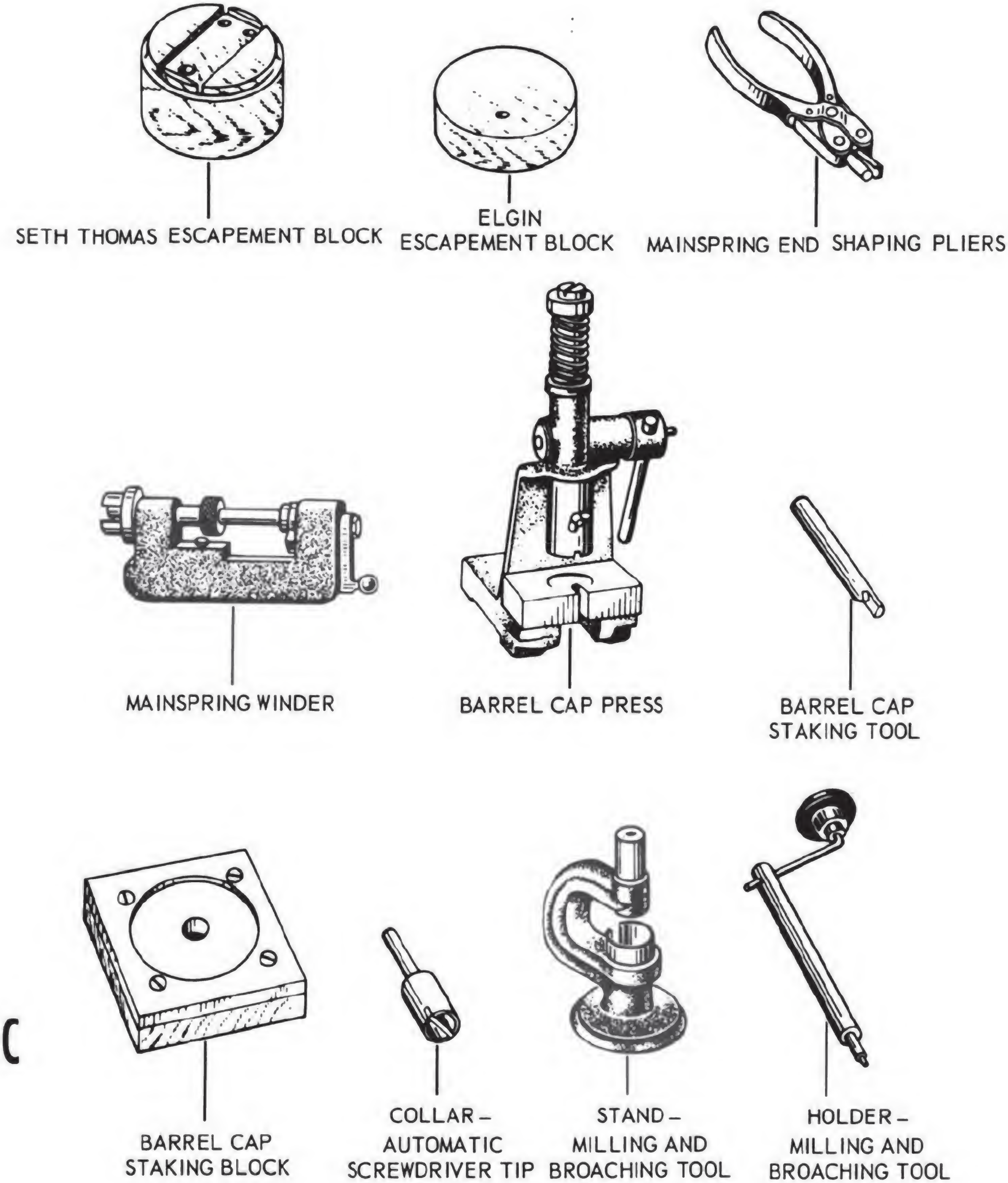


Figure 9-7.—Clock repair tools.



91.239

Figure 9-7.—Clock repair tools—continued.



91.239

Figure 9-7.—Clock repair tools—continued.

Always completely overhaul a clock whenever it: (1) receives physical damage, (2) will not run, and (3) fails to keep good time. These symptoms indicate mechanical trouble which should be remedied immediately in order to prevent more extensive damage. The general rule for overhauling a clock is: IF POSSIBLE, COMPLETELY OVERHAUL EACH CLOCK ONCE PER YEAR; EVERY CLOCK MUST BE OVERHAULED AT THE END OF A TWO-YEAR PERIOD. This rule always applies, even though a clock appears to be in perfect working condition. The reason for this is that foreign matter or gummy oil causes damage to parts which run at rapid speed, such as the balance wheel, which swings 300 times each minute.

The overhaul procedure for clocks is normally broken down into disassembly, cleaning, escapement operation, reassembly (no repairs required), testing, and adjusting. Repairs, of course, must be made as required, including the replacement of parts, which is the general rule.

When clocks are brought to the instrument shop for overhaul and repair, place each clock in one of three categories:

1. Operating condition—sent in for routine cleaning, oiling, and adjusting.
2. Non-operating condition—clock has not met with an accident.
3. Accident damaged mechanism—mechanism of such a clock should be inspected closely during cleaning, to determine the extent of damage, and to decide what action to take with respect to it.

Preliminary Disassembly

The removal of a clock movement from its case and the removal of hands and dial components from the movement constitutes preliminary disassembly. The purpose of this phase of disassembly is to enable you to make a preliminary inspection of the movement. The procedure for doing this work follows:

1. Unscrew the case knob which secures the bezel to the case and swing the bezel open.
2. Remove the three reflector screws which hold the reflector on the dial and the movement in the case.
3. Place a winding key or mainspring letdown key in the dial winding hole and lift up (with tilting and twisting motion) one edge of the dial enough to enable you to grasp it with your fingers.
4. Remove the movement from the case and put it (dial side up) on a movement work block.
5. Use a pair of hand removers (with felt pads) to pry off the hour, minute, and second hands (fig. 9-8).

91.240
Figure 9-8.—Removing hands from a clock.

6. Tilt the dial and movement sufficiently to enable you to remove (with needle-nose pliers) the grasshoppers which hold the dial. See figure 9-9. Then pull the grasshoppers off the dial feet.
7. Lift off the dial with the attached dial ring.

Observe in figure 9-9 the position of the hour and minute wheels and the cannon pinion. Perpendicular lines indicate where they fit on the plate.

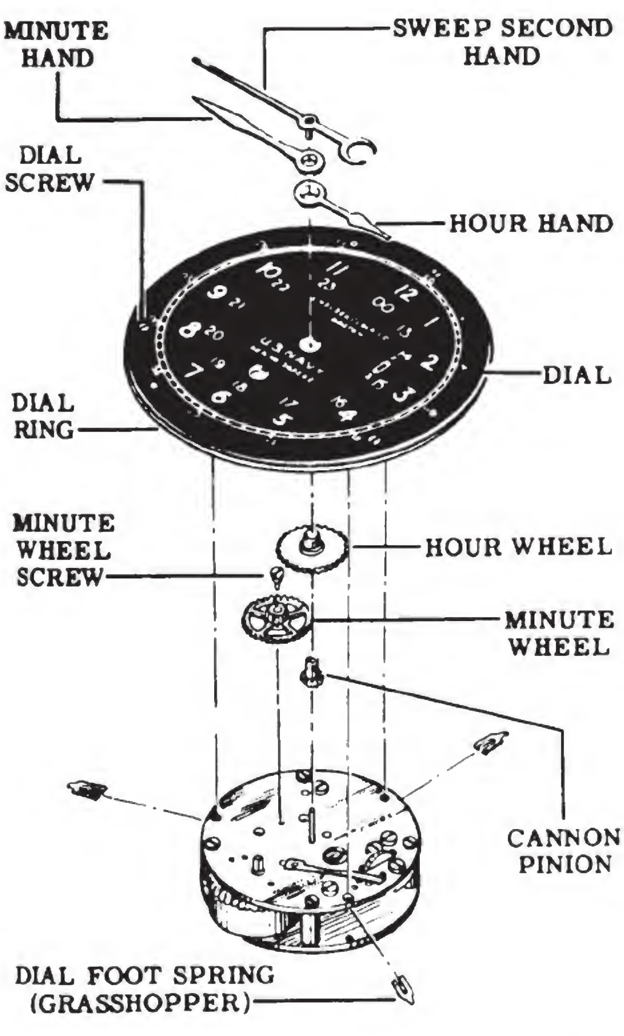
Pre-disassembly Inspection

Preliminary (pre-disassembly) inspection of a clock movement follows preliminary disassembly. The purpose of this inspection is to determine whether the movement is worth overhauling and to locate trouble within the movement. (Further inspection of mechanisms and parts takes place during cleaning and reassembling.) Difficulties located during the preliminary inspection should be entered on a

route ticket, to make certain that they will be found and corrected during regular overhaul and repair. The preliminary inspection also affords an opportunity for recording statistics on the performance of clock components.

The procedure for making a preliminary inspection follows:

1. Check the clock movement for gumming of oil, corrosion of parts, and physical damage; that is, all parts you can see and examine at this point of disassembly.
2. Check the cannon pinion for clearance with the front plate.
3. Test the tension of the click spring.
4. Check all parts for clearance, and screws for tightness.



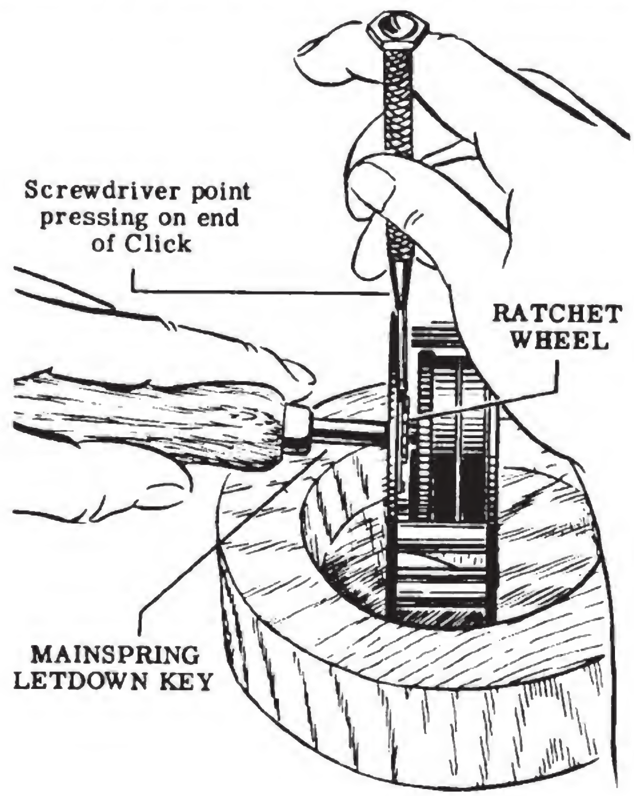
91.241
Figure 9-9.—Removing grasshoppers from dial feet.

5. Based on the findings of your inspection, make a decision as to whether the clock should be overhauled or surveyed, and parts salvaged.
6. Indicate on your job order the specific movement parts to be checked and your recommendations for replacement during inspection and readjustment when reassembly is accomplished.
7. Enter on the job order your recommendations for the escapement relative to replacement. Enter the names of specific parts which should be checked.

Disassembly of Movement and Escapement

During disassembly of a clock movement, put all parts in cleaning trays as you remove them. This action is necessary in order to prevent loss of or damage to parts.

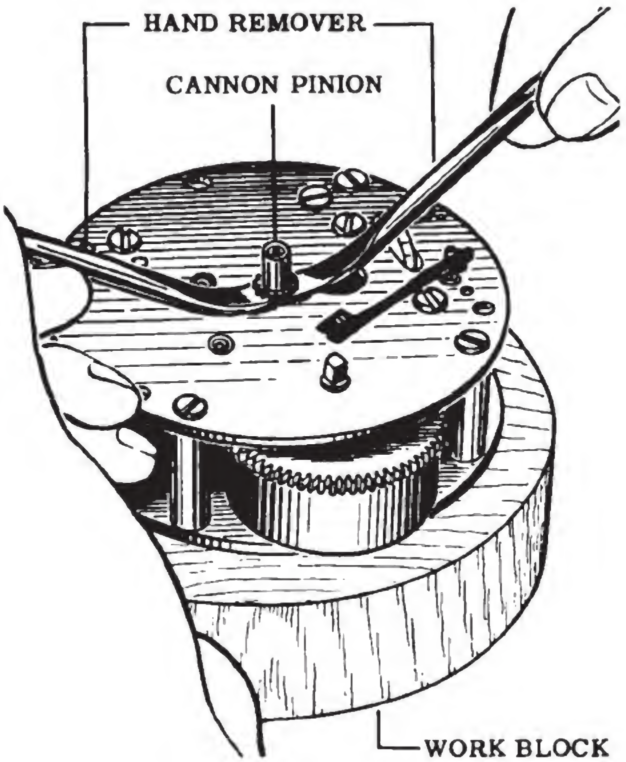
The first step in disassembly is release of the mainspring. To release the spring, put the movement on its side in a work block, as shown in figure 9-10. Then place a mainspring letdown key over the square end of the barrel arbor and turn it about 1/8th turn clockwise



91.242
Figure 9-10.—Releasing power of clock mainspring.

while you disengage the click from the ratchet wheel on the barrel arbor with a small screwdriver held in the other hand.

Turn the movement dial side up in the work block and unscrew the minute wheel screw and remove the minute wheel. Then use hand removers with felt pads (fig. 9-11) and remove the cannon pinion from the center arbor.

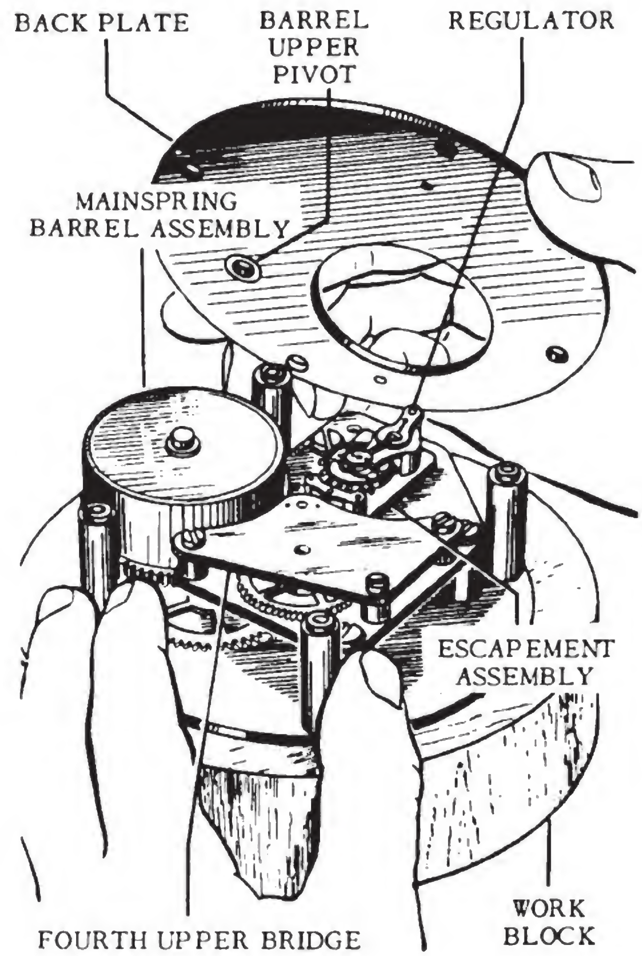


91.243
Figure 9-11.—Removing a clock cannon pinion.

Next, turn the movement over (back plate up) and unscrew the four backplate screws. Then remove the back plate and lift out the mainspring barrel assembly and ratchet wheel. Study figure 9-12.

To remove the barrel cap, hold the barrel in one hand and lightly tap the end of the barrel arbor which protrudes farthest through the cap with a wood or plastic hammer (not steel). The shoulder on the arbor transmits the force of the hammer to the cap and drives it out. Then remove the barrel arbor hook.

Place the barrel (with mainspring) on a mainspring winder and engage the inner end of the mainspring with the hook on the turning



91.244
Figure 9-12.—Removing back plate from clock movement.

shaft of the winder. Wind enough spring on the winder to provide sufficient space inside the barrel for the portion of the winder which holds the outer turn of the mainspring.

When the mainspring is securely held by the winder, turn the barrel back and forth to disengage the outer end of the mainspring from the barrel hook. Pull off the barrel. Then hold the winding handle of the winder and release the click, but prevent the spring from unwinding. Unwind the mainspring by slowly turning the handle of the winder. As you unwind the spring, pull on the outer end to get it out of the barrel.

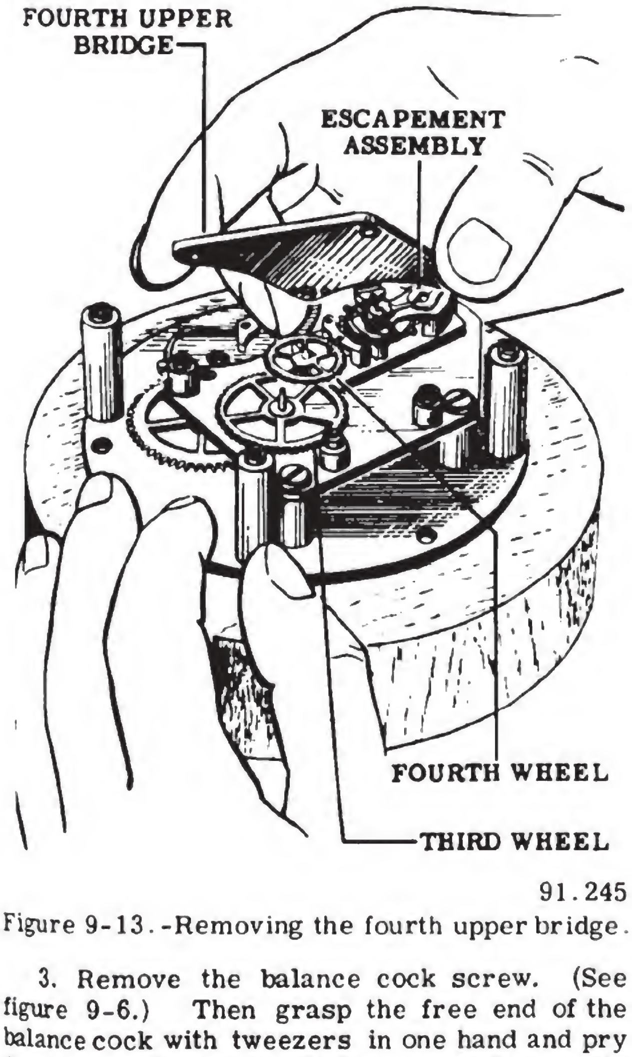
NOTE: DISCARD the OLD mainspring, unless circumstances require that it be reused.

(The mainspring barrel and its components are illustrated in figure 9-3.)

Next, unscrew the fourth upper bridge screws and remove the fourth upper bridge (fig. 9-13).

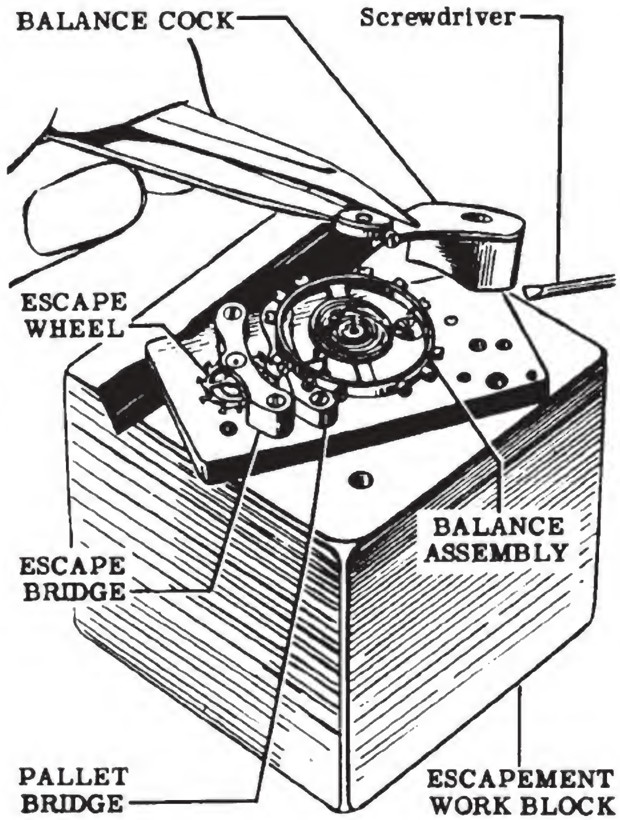
Insert a screwdriver through the work holes in the front plate and unscrew the two escapement mounting screws. Then remove the escapement and disassemble it, as follows:

1. Put the escapement on a work block and pry off the regulator with a small screwdriver. Leave the balance upper endstone cap in position. Put each part in the proper cleaning tray when you remove it.
2. Unscrew the hairspring stud screw enough to release the stud from its notch in the balance cock. Then slide the stud out with a pair of fine tweezers and retighten the stud screw.



91.245
Figure 9-13.-Removing the fourth upper bridge.

3. Remove the balance cock screw. (See figure 9-6.) Then grasp the free end of the balance cock with tweezers in one hand and pry (two prying holes) the balance cock loose with a small screwdriver held in the other hand, as shown in figure 9-14.



91.246
Figure 9-14.—Prying the balance cock loose.

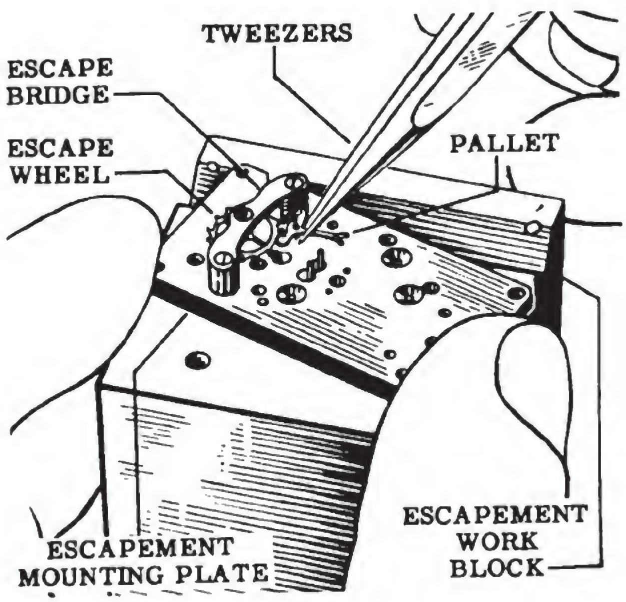
4. Using a pair of tweezers, lift out the entire balance wheel assembly and put it in a separate tray.
5. Unscrew the two pallet bridge screws. Then grasp the bridge in the middle with a pair of tweezers and pull up while you pry it loose with a screwdriver in the other hand. Remove the pallet with a pair of tweezers (fig. 9-15).
6. Unscrew the escape bridge screws and remove the bridge in the same manner you removed the pallet bridge. Then lift out the escape wheel.

Now, lift out the fourth and third wheels (fig. 9-16). Then remove the train plate screws and lift off the train plate. Study figure 9-17. Lift out next the intermediate and center wheels and remove the regulator gear (if not already removed). Check the position of these parts in figure 9-18.

For cleaning purposes, no further disassembly is necessary. The train and back plate pillars, the click, click spring, regulator block, and the index wheel may remain in position, as shown in figure 9-18. For better cleaning of the

click, turn it in a clockwise direction until the curved end of its spring is locked against the flat end of the click.

All parts of the case components, including the dial, hands, and the escapement, should now be in the parts tray. All parts of the movement, except the escapement, should be in the cleaning tray.

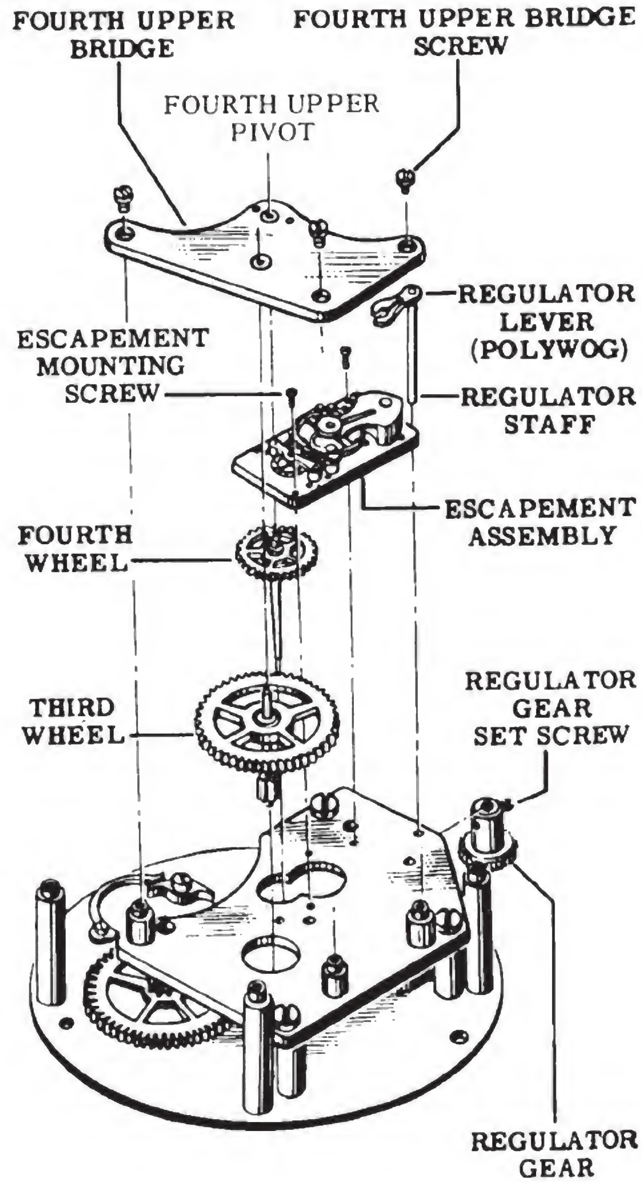


91.247
Figure 9-15.—Removing the pallet with tweezers.

CLEANING PROCEDURE

It is impossible to lubricate a clock properly unless the movement is perfectly clean. Even a fine film causes oil to spread, leaving pivots dry and subjected to unnecessary wear. Oil or gummy oil (especially if dust-contaminated) on pivots and other moving parts causes wear, erratic operation, and loss of power. Because the balance wheel of an average timepiece swings 157,680,000 times each year, and other wheels swing in proportion, one microscopic grain of grit in bearings or on pivots can be injurious.

During the pre-disassembly inspection, you made notations of defects in parts on the job order. Recheck the parts on which you made notation, and also check other parts which you could not inspect closely during inspection. Do NOT clean parts which are worn, damaged, or badly corroded—REPLACE THEM WITH NEW PARTS. Before you clean parts in a cleaning



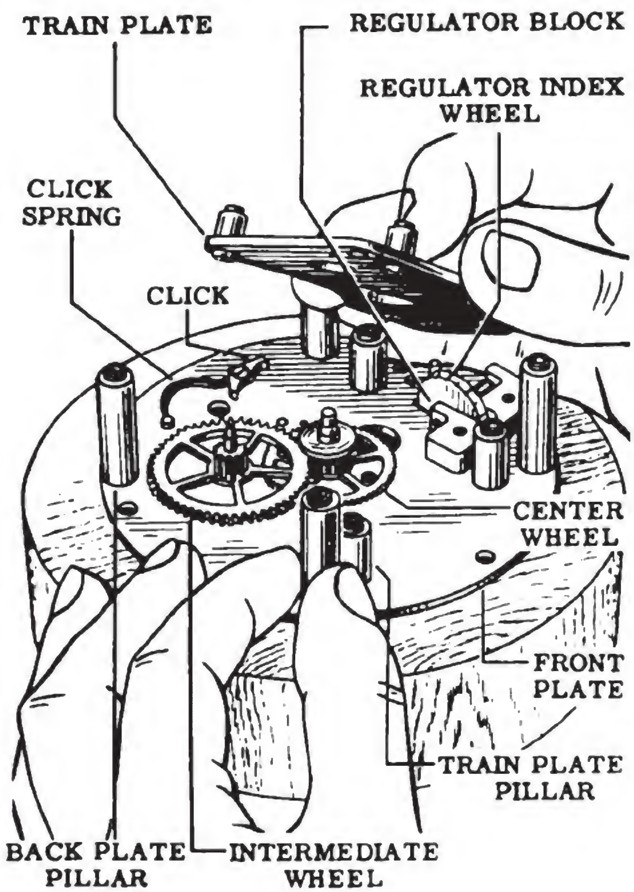
91.248
Figure 9-16.—Removal of third and fourth wheels.

machine, be sure to remove gummy residue from bushings with pegwood.

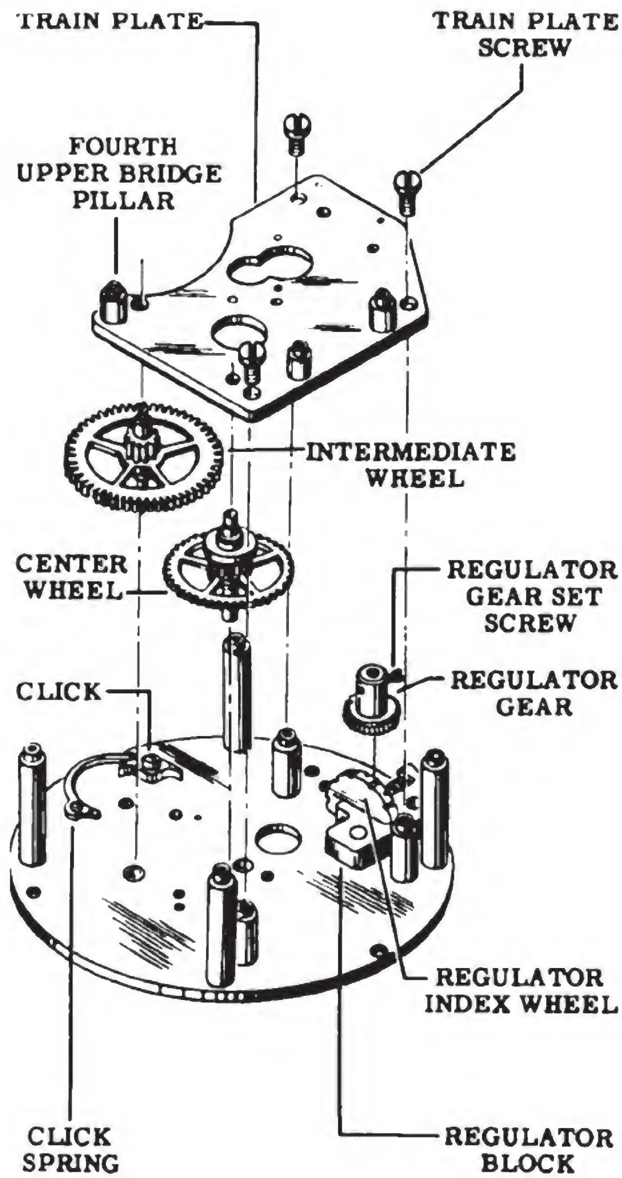
If suitable sealed containers are not available for stowing cleaned parts, do NOT clean them MORE THAN ONE DAY in advance of reassembly. This rule is MANDATORY.

Cleaning by Machine

At one time many clock parts were cleaned by hand. This method was adequate, but it was



91.249
Figure 9-17.—Removal of train plate.



91.250
Figure 9-18.—Removal of center and intermediate wheels.

a slow, painstaking task (process). Through experience, Instrumentmen learned that machine cleaning of watch and clock parts is fast, requires little skill, and is satisfactory. By the machine method, all clock parts can be cleaned at the same time. The ONLY parts you need to clean by hand are dials, hands, cases, mainsprings, and plates.

One type of instrument cleaning machine is illustrated in Instrumentman 3 & 2, NavPers 10193-B. Review the description and operating procedure of that machine, and then study figure 9-19, which shows a large cleaning machine with the cleaning basket and trays which fit in it. Note the 3 wedge-shaped trays (one with divider) and the separating cover beneath them. If these trays are put in the bottom of a large cleaning basket and the cover is placed over them, other parts can then be put on top of them in the basket before it is secured in the machine.

Study the diagrams in figure 9-19 which show how clock parts should be placed in the trays and the basket for cleaning. Follow these instructions.

Do NOT overcrowd parts in cleaning trays. Parts should not contact each other in a manner that impedes good cleaning. Do NOT MIX escapement parts in trays with other parts. KEEP THEM SEPARATE.

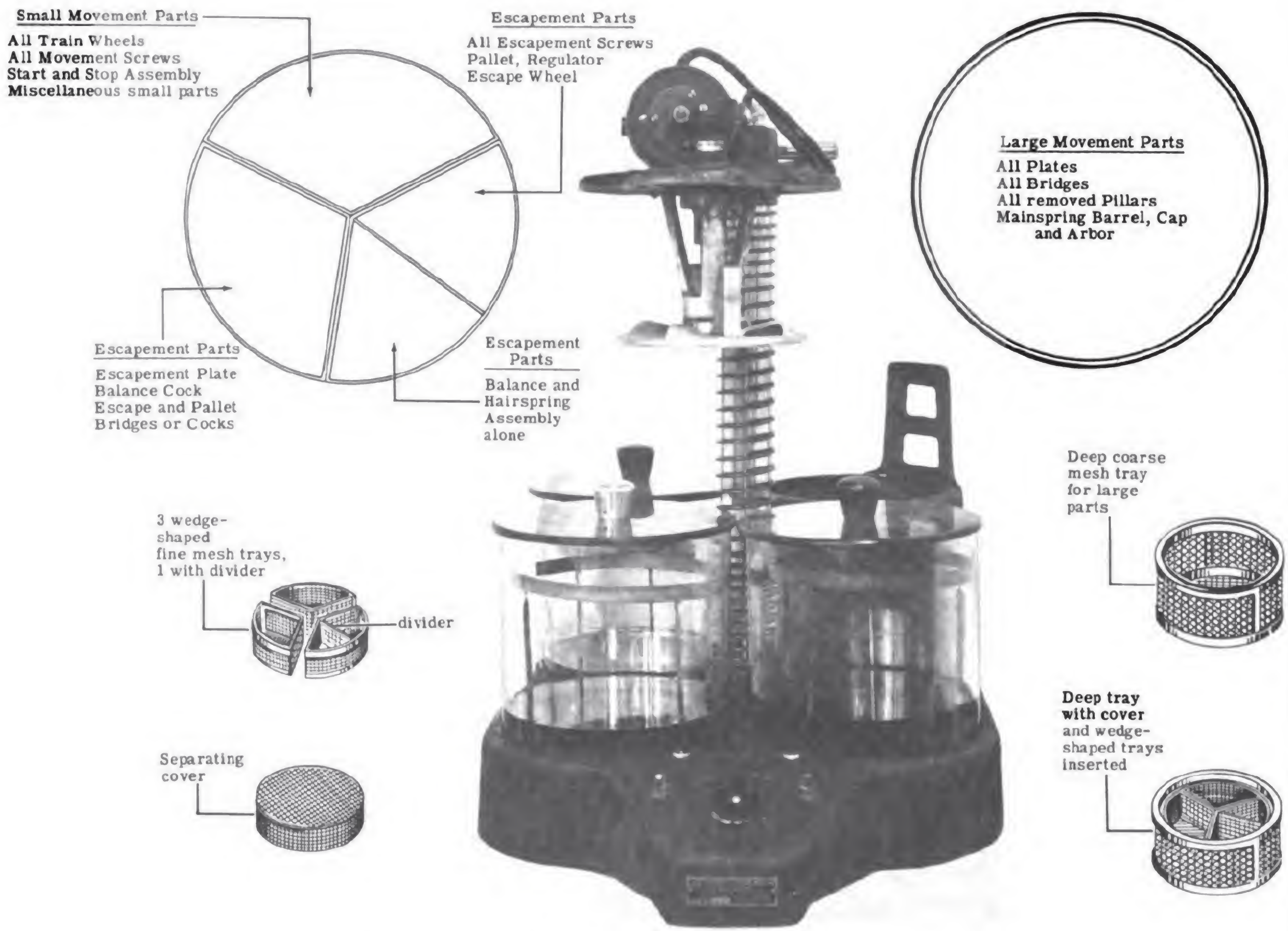


Figure 9-19.—Cleaning baskets of an instrument cleaning machine. 61.101

Use the following procedure for cleaning clock parts with a machine.

1. Put enough cleaning solution (made in accordance with instructions) in one container to cover the largest basket. Always use a recommended cleaning agent.

2. Put enough rinsing solution in two cleaning jars (of the machine) to cover the largest parts basket.

3. Secure a basket of parts to the spinner motor of the machine and lower the basket into the cleaning solution. Then run the machine for three minutes. NOTE: If the machine has a timing device equipped with an alarm, set it for a three-minute run.

4. Raise the basket of parts out of the cleaning solution and spin it (in the machine container) a few moments to eliminate excess cleaning solution from the parts. Then lower the basket into the first rinsing solution and spin it for one minute. NOTE: Eliminate excess rinsing solution from the parts in the same manner you used to eliminate the cleaning solution.

5. Remove the basket of parts from the first rinse and spin it for one minute in the second rinse.

6. Remove the basket of parts from the second rinse and spin it for at least four minutes in the drier. NOTE: It is best to turn on the drying chamber of the machine as soon as you start to clean parts, so that the chamber will be hot when you need it.

CAUTION: If you leave clock parts in the cleaning and rinsing solutions longer than recommended, you may etch them.

Use tweezers to handle clean watch and clock parts. Remove lint with a compressed air hose. Check parts for remaining residue, especially inside bushings and pivots. If necessary, clean the bushing with a soft piece of pegwood, and press the pivots into clean pith.

Stow clean clock parts in sealed or covered containers to protect them from foreign matter.

Cleaning by Hand

Use a clean, damp cloth to clean the dial, the hands, and the case of a clock. Remove dried oil or grease with a clean cloth dampened with naphtha or cleaning solution. CAUTION: Do NOT rub the dial numbers OFF, or the luminous dots next to the numbers.

If you must reuse a mainspring, remove gummed oil on it with a clean cloth dampened with naphtha or cleaning solution; then dry it with a clean cloth. NOTE: Work the cloth between the turns of the spring to ensure cleanliness of the entire surface. This rule applies to both cleaning and wiping.

INSPECTING AND REPAIRING

Inspecting (after cleaning) and repairing are considered together in this section because they are interrelated, and because very few repairs are authorized for Navy clocks. Repairs are expensive and tend to destroy the standard dimensions of a clock part. Besides, it is generally more economical to replace a defective part with a new one. Do NOT MAKE REPAIRS TO PARTS THAT REQUIRE MACHINING. This is the policy with respect to all clock parts. Replace parts with functional defects or structural weaknesses.

After you clean clock parts, re-inspect them for defects that you might have missed during the first inspection.

Indicate on each job order what action you took relative to defective clock parts.

Use the following check list for inspecting a clock case and dial components, the movement, and the escapement.

Inspecting the Case and Dial

1. Inspect cases and bezels for cracks, breaks, chips, and damaged hinge lugs. Replace damaged parts, as stated previously.

2. Check cases, bezels, back plates, and bulkhead plates for scratches, chips, and damage to the finish. These blemishes can be removed, but replace scarred hinge pins and case knobs.

3. Inspect the glass in the bezel. (Remove locking wire.) If the bezel is broken, cracked, or badly scratched, replace it. Use waterproof cement to secure it. NOTE: The permoseal crystal on boat and deck clocks is NOT replaceable; REPLACE the entire case.

4. Inspect the cork and rubber gaskets used to seal the case, and also the rubber disks used for shock mounting. If these are brittle, cracked, or broken, replace them.

5. Inspect the dial and ring for deformities, or breakage. Replace defective parts, and use paint to touch up chips on numerals.

6. Check the hour, minute, and second hands for bends, cracks, and deformities.

7. Recheck all notations made on the job order about the case and dial, and enter on the ticket the action you took in each instance.

Inspecting the Movement

Make the following checks on a clock movement:

1. Inspect the pivots of the train wheels. If the pivots are worn, scored, bent, or broken, replace them.
2. Check the teeth and pinions of the train wheels. Replace parts with deformities.
3. Inspect each staff and fit of each wheel on its staff. Replace loose wheels and wheels with bent staffs.
4. Check the teeth on the barrel and the cannon pinion, the ratchet, minute, and hour wheels. Check also the teeth on the regulator gear and the threads on the regulator index wheel worm screw. Inspect teeth on the setting pinion.
5. Inspect the barrel hook for looseness. If the hook is loose, check for bent teeth. If a bent tooth is located, replace the barrel. If the hook is loose and no other deformity exists, tighten the hook by peening over the rivet.
6. Check the start and stop springs and shafts for corrosion, deformities, and breakage.
7. Inspect the plates and bridges for bends, cracks, and corrosion.
8. Replace pillars, screws, arbors, and so forth, which are corroded, worn, bent, or broken.

Inspecting the Escapement

Inspect all parts of the escapement in the following manner:

1. Check the endstones for pits, chips, cracks, and breakage. Replace broken and defective parts.
2. Inspect the hole jewels for chips, cracks, wear, and breakage.
3. Use a pair of tweezers to inspect the tightness of banking screws. If they are loose, remove them and insert new banking screws.
4. With an eye loupe of high power, examine the escape wheel for bent or scored pivots and worn escape teeth. If defects are noted, replace the escape wheel.
5. Check for sideshake and endshake in the escape wheel. The procedure for correcting this trouble is explained in chapter 10 of this text.
6. Examine the pallet for chipped, loose, or mal-positioned jewels. Check the pallet pivots for bends or defects, and the guard pin for fit and alignment. Reset the pallet jewels, if necessary; replace defective pallets. No other repairs to the pallet are recommended.
7. Examine the roller jewel for cracks, chips, alignment, tightness, and breakage. Check the safety roller for tightness. If the roller or roller table is loose, replace the loose roller.
8. Inspect the balance pivots for bends and defects. If any exist, replace the balance staff.
9. Inspect the balance and timing screws for tightness. If a screw is damaged, replace it; if threads are stripped in the balance wheel, replace the wheel.
10. Check the balance wheel for trueness in the round and in the flat. If it is noticeably out of round, replace it; if it is not true in the flat, make necessary correction by bending one or both balance arms.
11. Check the balance for poise. Saw, file, or undercut screws (as necessary) to make corrections. When required, use a washer under a light balance screw to add weight to the balance wheel at that point.
12. Check the shape of the hairspring. Make minor corrections by bending with tweezers. If necessary, replace the entire hairspring assembly.

REASSEMBLY AND OILING

As you learned in Instrumentman 3 & 2, NavPers 10193-B, the procedure for reassembling a clock or watch is accomplished in the reverse order of disassembling. Consult the manufacturer's technical manual for the timepiece concerned when you do this work, as necessary.

One important part of reassembly of a clock is the inspection of parts for fit and tightness. Another important aspect of reassembly is oiling, for at this time you can get to the places which require oil. For this reason, reassembly and oiling are considered together in this section.

Clock Lubricants

A good clock oil is an absolute necessity, but there is no such thing as a PERFECT clock oil. Even the best types of oils have some undesirable characteristics; and for this reason, it is always best to use ONLY the lubricants recommended by the manufacturer or the Navy

for a particular timepiece. A good clock oil does NOT:

1. Spread (draw away from pivots).
2. Become gummy during usage.
3. Evaporate from parts.
4. Oxidize or corrode metals.

Remember to keep your main supply of clock oil tightly covered and away from light, to protect it from foreign matter and the power of sunlight. Also, guard it against any type of contamination.

When oiling a clock, put a small amount of oil in an oil cup, preferably one with a cover, and protect it from dirt. Keep the cover on tight when you are not actually using the oil.

Proper care of clock oil cannot be over emphasized. Dirty oil causes abrasions on pivots and becomes gummy during use much faster than clean oil.

CAUTION: Because clock oil is cheaper than parts, it is best to discard unused oil from the oil cup at the end of each day's work.

You can make a clock oiler from a piece of steel wire, or use a good commercial one. A flat, notched point on an oiler is best; for the notch holds the oil at the tip of the oiler. It is also a good idea to push the oiler into a piece of clean pithwood before you dip it into the oil cup, not only to clean the oiler but also to enable you to judge better the amount of oil you get on the tip of the oiler.

Oiling Procedure (with Inspection)

The oiling of clock parts during reassembly (with necessary inspection) takes place in logical order. Before we discuss the various steps in the oiling and inspecting procedure, however, it is best to stress the importance of the method followed for oiling bearings and bushings.

When you oil a train bearing, ALWAYS TOUCH THE BUSHING and the PIVOT at the same time, for this causes the oil to flow through the bushing hole and around the pivot, as shown in part A of figure 9-20.

As you remove the oiler from a bushing hole, lift it straight up to avoid a track of oil across the bushing to the surrounding metal. If you do leave such a track, the oil is drawn away from the pivot and out to the surrounding metal (part B, fig. 9-20). If you put too large a drop of oil in the bearing, the oil flows through the hole and over the pivot shoulder, the arbor, the pinion, and through the teeth of the movement. See part C of figure 9-20.

You will recall that during disassembly some parts were left on the front plate because it was not necessary that they be removed. You should therefore start to reassemble the clock mechanism by inspecting these parts, and then continue with the oiling and inspecting procedure until the entire mechanism is assembled. Inspection at this time is most important, because it is your last chance to check for blemishes and damage you previously overlooked (if any) during the overhaul and repair process. The parts in a clock mechanism which you should inspect and oil during reassembly are as follows:

1. Inspect the back plate pillars for tightness.
2. Check the click spring for the amount of pressure it exerts. If necessary, bend this spring to increase the pressure it exerts on the click, to ensure positive engagement with the barrel ratchet wheel.
3. Oil the corners of the center wheel friction spring.
4. Inspect for uprightness of the center and intermediate wheels in their pivot holes; test for tilt in four directions.
5. When you have the center and intermediate wheels in position, check them for freedom of action in their pivot holes. Check these wheels also for ENDSHAKE.
6. Oil the upper pivots of the center and intermediate wheels. See figure 9-21.
7. After you have the fourth wheel in position, oil its staff.

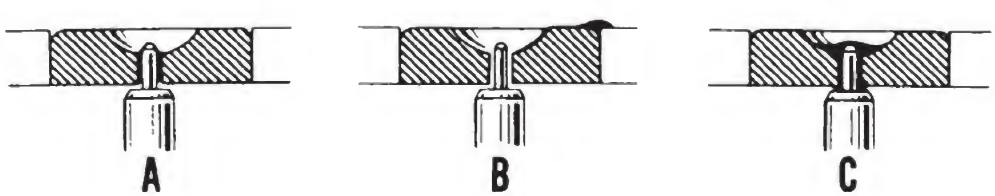


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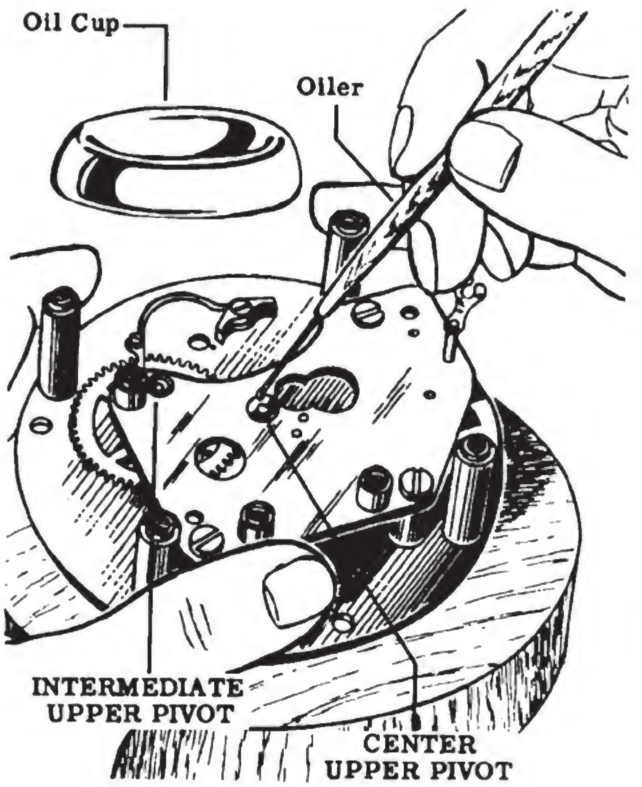
Figure 9-20.—Proper way to oil a bearing.



91.252
Figure 9-21.—Oiling upper pivots of center and intermediate wheels.

8. Check for endshake and sideshake in the third and fourth wheels. Oil the upper pivots of these wheels.

9. When you have the mainspring wound into the barrel, use an oil can with a fine spout to apply a thin stream of oil across the edges of all coils, straight across the top of the mainspring. NOTE: Add the oil before you insert the barrel arbor. As the spring is wound later, the oil spreads evenly over the mainspring and inside the barrel. CAUTION: If you use TOO MUCH OIL, it may be forced out of the barrel when the mainspring is wound tightly.

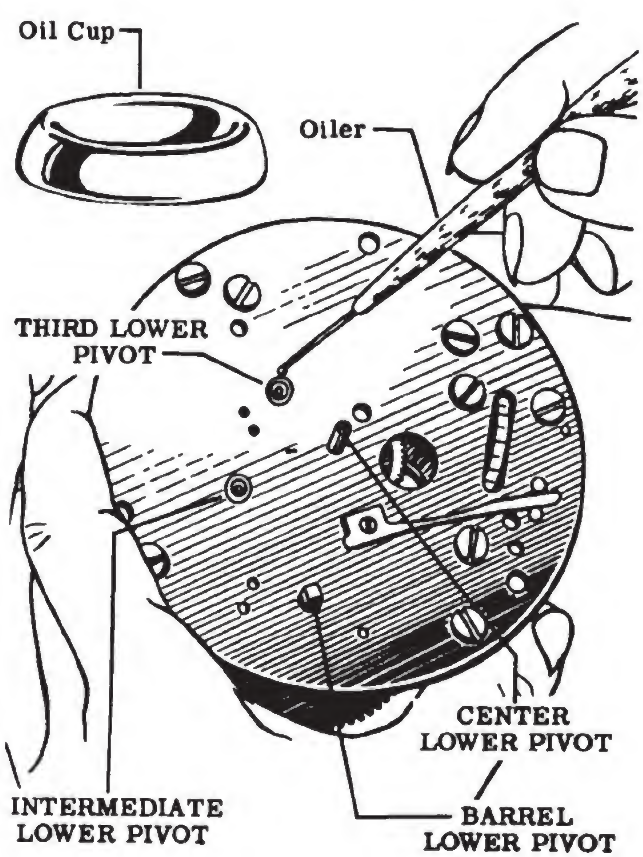
10. When you insert the barrel arbor, check for endshake and sideshake. Turn the arbor several times to make certain that the barrel hook and arbor hook engage the mainspring inside the barrel.

11. Oil the arbor bearings.

12. After you have the ratchet wheel in position, check the engagement of the click.

13. When the back plate is in position, oil the barrel upper pivot and the fourth upper pivot.

14. Put the clock movement dial side up in the work block and oil the center, third, and intermediate lower pivots (fig. 9-22).



91.253
Figure 9-22.—Oiling lower clock pivots.

The procedure for inserting the cannon pinion with a cannon pinion pusher is shown in figure 9-23.

Whenever you are in doubt about any part of a clock mechanism, or any procedure you take with respect to disassembly, cleaning, repairing, reassembly, oiling, and adjusting, ALWAYS refer to the manufacturer's technical manual for the clock on which you are working. The best plan is to follow this rule until you know the mechanism well enough that you can do the work without any questions in your mind.

Recheck the job order for the clock, to make certain that all recommendations pertaining to it have been initialed, indicating that the work was accomplished.

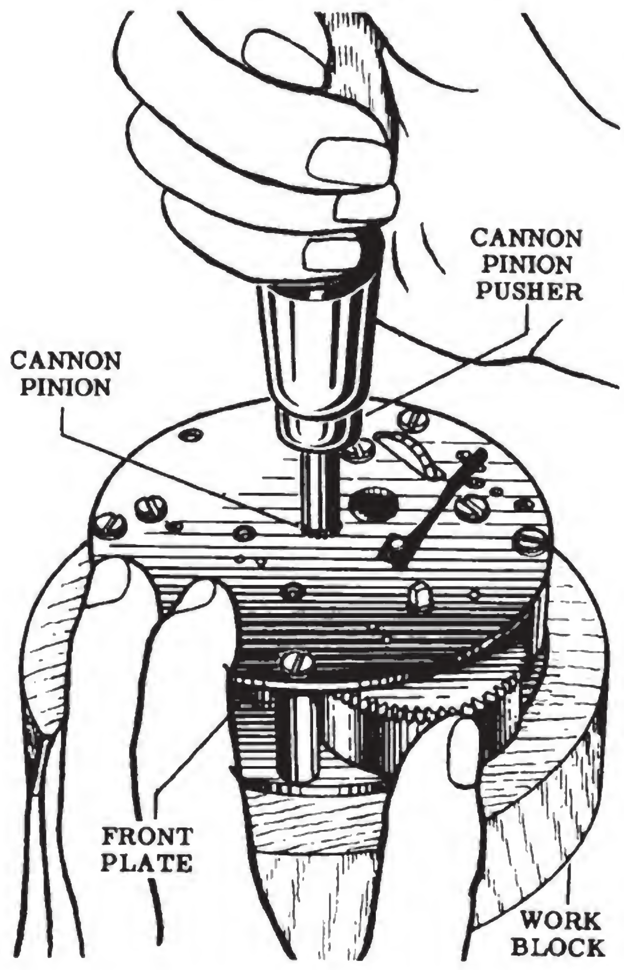


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Figure 9-23.—Inserting a cannon pinion with a pusher.

CHAPTER 10

WATCH AND CLOCK ADJUSTMENTS

Watches and clocks used aboard ship and throughout the Navy must be reliable and accurate; and when maintained in excellent operating condition, they generally have these attributes. As an Instrumentman, it is your responsibility to overhaul and repair watches and clocks, including proper adjusting and regulating.

Before you can qualify for advancement to a Chief Instrumentman, you must know such things about watches and clocks as common causes of motion variation between dial-up and 12-up positions, operation of a watch rate recorder and interpretation of data obtained thereby, and the accepted techniques of testing for and correcting positional and isochronal errors. This chapter, therefore, provides the information you must know in order to adjust watches and clocks.

Watch and clock adjusting may be defined as the ELIMINATION OF CONDITIONS in a watch or clock which affect the degree of accuracy of which the timepiece is capable. Watch adjusting is normally limited by definition to the correction of errors or faults in the hairspring and balance wheel which interfere with accurate timekeeping. This definition, in essence, is true; because the balance assembly is the timekeeping mechanism. The mainspring, the main train, and the escapement serve only to keep the balance in motion. When these parts of a timepiece are functioning perfectly, adjusting does consist of the correction of conditions which adversely affect satisfactory operation of the balance assembly.

Adjustments made on watches and clocks to improve their accuracy are generally classified under three headings:

1. Temperature adjusting (compensations for).
2. Isochronal adjusting (elimination of isochronal errors).
3. Position adjusting (adjustments with PENDANT UP, PENDANT DOWN, DIAL UP, and so forth).

These three types of adjustments are discussed in detail in this chapter. At this time, however, it is best to take into consideration the operation of a watch and clock timing machine, and to explain how data obtained by testing a watch or clock on this machine can be used in making adjustments to the timepiece.

TIMING MACHINE

A timing machine is a mechanism which records the operation of a mechanical timepiece on a strip of special chart paper. One type of timing machine is illustrated in figure 10-1. Observe the nomenclature, and the dialed movement in a special clock holder (illustrated in figure 9-7).

A timing machine makes a dot on the chart every time the timepiece undergoing a test TICKS, and it can determine in 30 seconds how FAST or SLOW it will run in 24 hours. The completed chart consists of a sequence of these dots across the chart.

TYPES OF TIMING MACHINES

There are two basic types of timing machines: (1) drum, and (2) continuous-tape. The one shown in figure 10-1 is a drum type, which makes a line of dots from left to right on a chart. Beneath the clamp which holds the clock on the machine is a sensitive pickup which detects the impulse from the escapement. When amplified by the timing machine, this impulse drives a stylus which prints the impulse on the chart. A perfectly adjusted escapement produces only one line on the paper, but some clock movements may produce records with double lines and still keep accurate time.

A continuous-tape timing machine makes a row of dots on a tape which unwinds from top to bottom. A vertical row of dots indicates

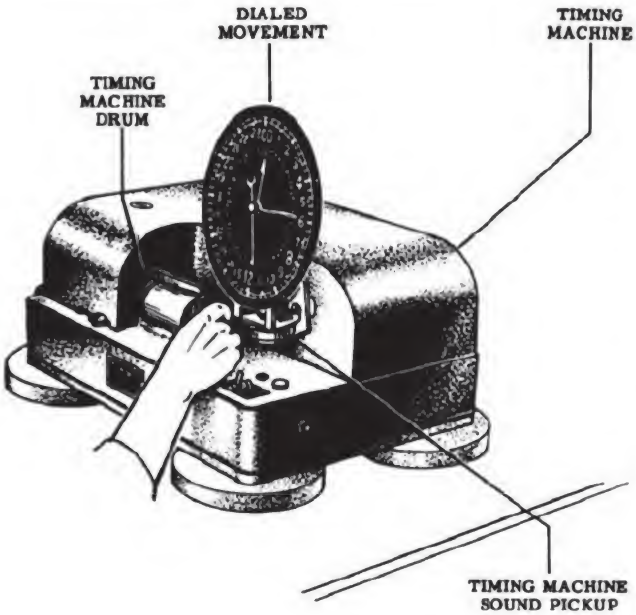

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Figure 10-1. —Timing machine.

NEITHER a GAIN nor a LOSS of time. If the row of dots slopes to the left, the timepiece is running SLOW; if the row of dots slopes to the right, the timepiece is running FAST.

TIMING MACHINE DATA

A timing machine chart record of ticks may be used to tell exactly how fast or how slow a watch is running; and the chart record may also be used by an experienced watch repairman to diagnose certain troubles in the instrument being tested.

By studying a chart produced on a continuous-tape timing machine, you can tell whether the timepiece undergoing a test is losing or gaining time by the angle of the row of dots away from the vertical line, which indicates perfect timekeeping. The angle indicates the number of seconds per day the timepiece is GAINING or LOSING. A convenient angle-measuring device graduated in seconds per day is mounted over the tape.

A horizontal line of dots on a chart produced by a drum-type timing machine indicates that a timepiece being tested is NEITHER LOSING nor GAINING time. When the row of dots rises upward (left to right), the instrument is gaining time. When the row of dots fall downward (left to right), the timepiece is LOSING time. The chart paper is marked with ruled lines which show the GAIN or LOSS per day in seconds, indicated by the rise or fall of the dots from the horizontal line.

Take a look now at figure 10-2, which shows four different records of a watch taken on a drum-type timing machine. Record A represents the watch EXACTLY on time. Record B shows that the watch is gaining 15 seconds per day. Record C represents the watch losing 30 seconds per day. Record D (prepared in 15 seconds) represents the watch losing 30 seconds per day.

Illustration 10-3 shows two different records of a timepiece. The double lines on this chart represent the difference in time between the TICK and TOCK, and the TOCK and TICK. When a timepiece is in perfect beat, this separation (two lines of dots) may be caused by excessive SLIDE of the escapement. In general, however, if the two lines are parallel, the timepiece is accurate.

Many watches have unpoised balance and hairspring assemblies, resulting in differences in rate in various vertical positions. Study figure 10-4. Records A, C, and E show a watch in acceptable condition. Records B and D show that the watch is out of balance in these particular positions. If the watch is not affected in positions A, C, and E (and the recordings of B and D are such that these two positions do not exceed accepted limits for this type of watch), the watch is acceptable.

Records A, B, and C of figure 10-5 show three positions of a watch in which the regulator

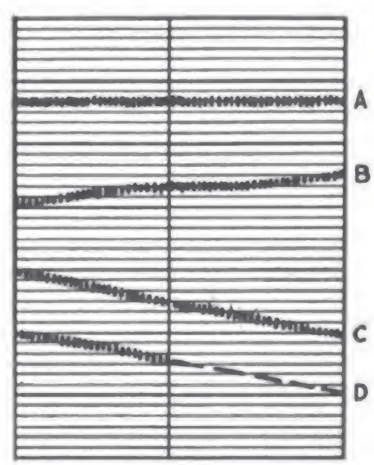

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Figure 10-2. —Timing machine records of a watch.

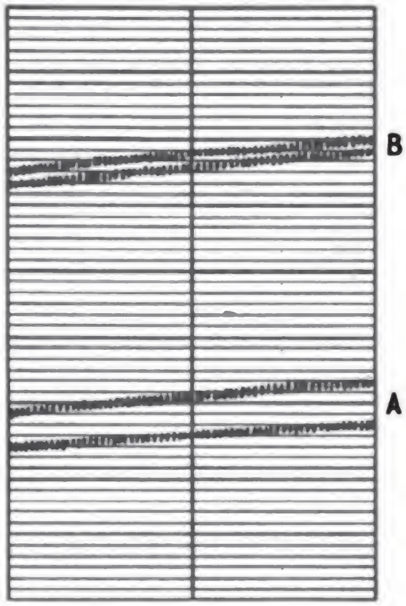

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Figure 10-3.—Two records of a watch which is gaining 15 seconds per day.

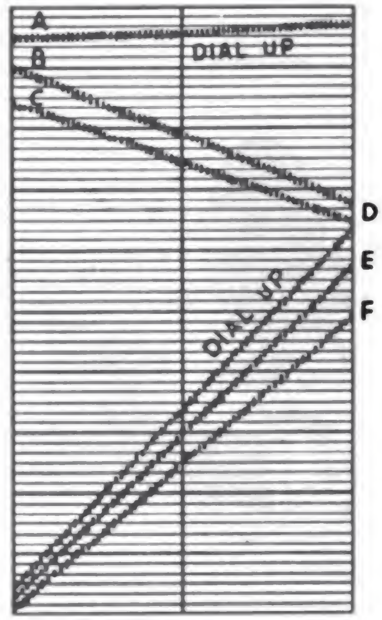

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Figure 10-5.—Record of a watch with improperly adjusted regulator pins.

pins may be excessively far apart. The horizontal rate is approximately correct, but the PENDANT DOWN (B) and PENDANT UP (C) rates are slow. Records D, E, and F show the

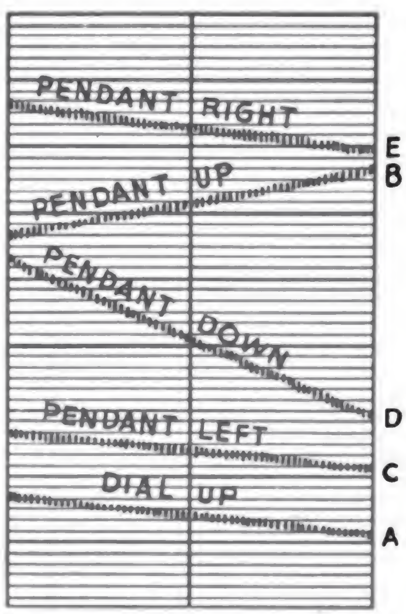

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Figure 10-4.—Record of a watch with an out-of-poise balance.

rate of the watch in the same three positions after the regulator pins were closed sufficiently to obtain proper action of the hairspring between them. Moving of the regulator pins in this manner has the effect of making the watch run faster in all positions, but the change in the vertical position rates is greater than the change in the horizontal position rates. This action brought the position error into ACCEPTABLE LIMITS. Records D, E, and F show that the watch is gaining 3 minutes every 24 hours in the horizontal position, but correction can now be made by adding balance weights, rather than by manipulating the regulator pins.

The hairspring is responsible for much of the ordinary trouble in a timepiece, particularly with respect to its relation with the regulator pins, and also in regard to defects in the escapement. Refer to figure 10-6. Record A of this illustration may indicate that the hairspring bears harder and longer against one of the pins. Record B may show that one of the pins is bent at an angle, or that trouble exists in the receiving stone of the pallet. Records B and C may indicate improper locking of the escapement. Record C may indicate trouble in the discharge stone of the pallet. Record D shows good adjustment of the hairspring and escapement, but

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Figure 10-6.—Record of a watch which has poor adjustment of the hairspring and regulator pins.

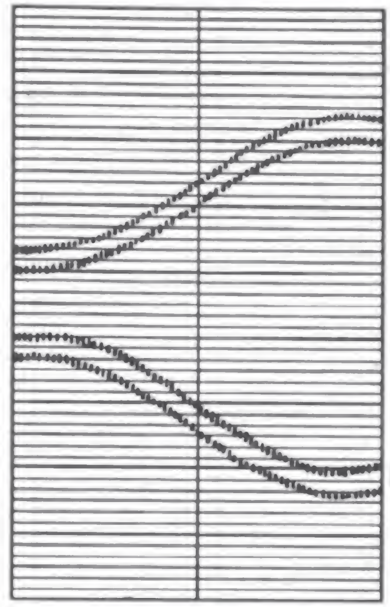

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Figure 10-7.—Rate record of a watch with defective fourth wheel or a binding second hand.

it may indicate that the movement would perform better if it were in beat. The lines on the chart would then be closer together, as indicated by record E.

The chart in figure 10-7 shows trouble in a watch caused by a defective fourth wheel or a second hand binding or rubbing on one side. If the fourth wheel (normally makes one complete revolution per minute) is out of round, or has a bent pivot or arbor, it causes a change in the amount of power delivered to the escape wheel and the balance assembly. This causes a change in the rate of the watch, as does the rubbing or binding of a second hand.

Next, study the record shown on the chart in figure 10-8, which shows that dirt or a binding in the main train or of the mainspring in the barrel is causing a change in the power delivered to the balance assembly.

Records A, B, and C in figure 10-9 may indicate that the escape wheel is out-of-round or has a burr on its pinion. Such a condition may cause a change 10 times per minute. Record A may indicate that the wheel is out-of-round or not exactly centered in its arbor. Record B may show that the pinion alone is defective and that the escapement is not affected thereby. Record C may indicate that the pivot or arbor is causing the trouble. Record D indicates that the escape wheel has a mutilated tooth but that adjustment of the watch is otherwise acceptable.

In figure 10-10 you see record A of a watch which shows a condition of overbanking (excessive balance motion); and also record B, which shows a record of the same watch after a new mainspring was installed.

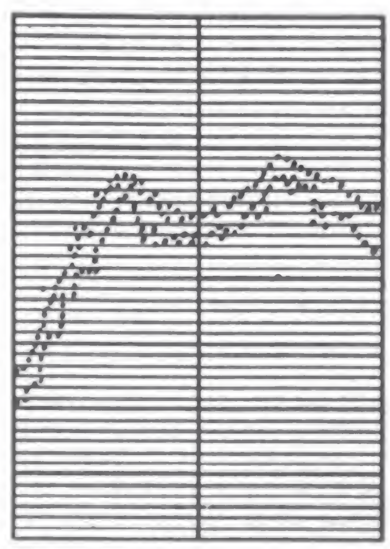

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Figure 10-8.—Record of a watch which has binding parts or is dirty.

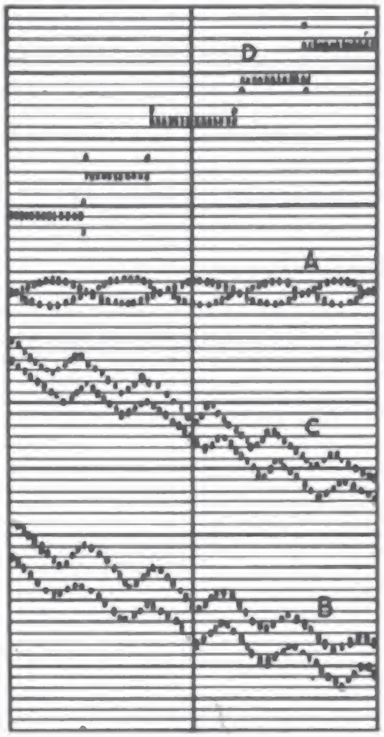

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Figure 10-9.—Record of a watch with an escape wheel out-of-round or with a burr on its pinion.

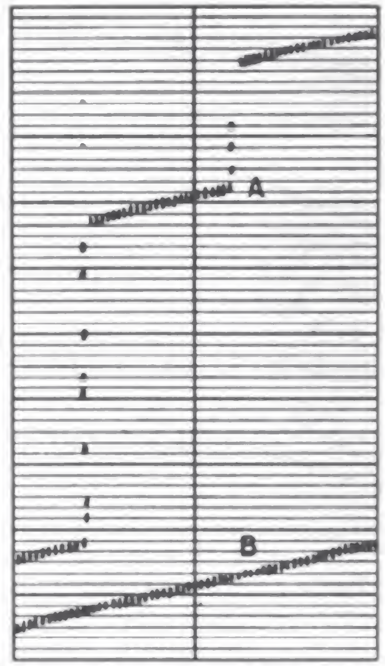

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Figure 10-10.—Record of a watch with excessive balance wheel motion (before and after correction).

Study next figure 10-11, in which record A may indicate that the watch has a loose pallet stone on the discharge side. Record B may indicate that the watch has a loose banking pin on the receiving side. In addition to these defects, the record may show excessive slide in the escapement. The upper or lower line of the record may be an indication of the side on which the slide must be reduced. Proper adjustment of the escapement will bring the lines together.

ADJUSTMENTS FOR TEMPERATURE

A balance wheel of a good watch today is made of solid, monometallic metal which requires no temperature compensation (adjustments). The same thing is true for a good clock. The wheel is made of brass or beryllium alloy. The hairspring used with the balance wheel is also made of metal or an alloy (nickel, steel, chromium) which is practically insensitive to normal temperature changes.

Because many watches and clocks in use today do not have the newest types of balances, it is necessary that you know how to adjust them in order to compensate for temperature changes. The first balances in watches did not have ANY MEANS built into them to compensate for changes in high and low temperatures. As a result, because metal expands when hot and contracts when cold, the balance wheel and hairspring (made of soft metal) expanded in diameter during hot weather and decreased in diameter during cold weather. The increase and decrease in the diameter of the balance wheel and hairspring made the watch run slower in hot weather and faster in cold weather.

Watch manufacturers then conceived the idea of making a balance wheel with built-in compensation for changes in temperature. They made the rim of the balance wheel of fused steel and brass, with the brass portion (about 3/5 of the total thickness) on the outside. Because the coefficient of expansion of brass is greater than that of steel, the free ends of a cut balance wheel made of these metals curl IN and OUT slightly with changes of temperature and therefore slightly change the diameter of the balance wheel.

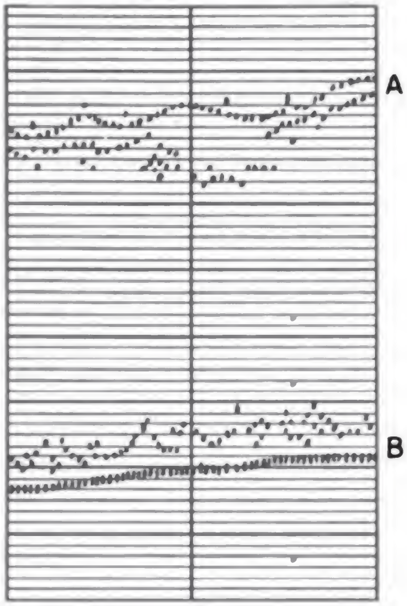

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Figure 10-11.—Record of a watch with defective locking of the escape wheel.

The ends of the balance wheel are forced outward during cold weather.

This type of balance wheel (bimetallic) was more satisfactory than the monometallic type, but the free ends were not forced inward to the same extent in INCREASED temperature as they were moved outward with DECREASED temperature. In other words, the bimetallic balance did not entirely meet the error in rate of running of a watch in hot and cold temperatures; so, other means were devised for obtaining a better compensation for temperature changes.

Temperature compensation in watches with bimetallic, cut balance wheels is obtained by balance screws in the rim. There are usually twice as many holes in the rim of the wheel as there are screws; so if the rate of the watch varies in different temperatures, you can compensate for the variation by moving the screws in opposite pairs closer to or farther away from the open ends of the balance. If a watch loses time in hot weather, shift opposite parts of screws TOWARD the open ends of the balance; if the watch gains in hot temperatures, shift opposite pairs of screws AWAY from the open ends of the balance.

ISOCHRONAL ADJUSTING

An isochronal hairspring applies torque on the balance staff directly proportional to the angle through which the balance turns—the energy stored in the hairspring by the impulse from the escapement releases itself in the form of equal torque on the balance staff. As used here, equal torque means that all of the energy stored in the hairspring is utilized in returning the balance wheel to its neutral position—no energy is lost to side thrust on the balance staff pivots. The purpose of isochronal adjustments, therefore, is to establish the force of the hairspring in a manner that will ensure an equal rate for the watch in the HIGH and LOW arcs of motion.

If a watch is properly adjusted for isochronism, it will run uniformly for 24 hours. It may gain or lose during this period, but it MUST run uniformly. Bends in the overcoil of a hairspring, as you learned in chapter 8, affect the isochronal qualities of the spring. Bends in the overcoil of a hairspring when the balance is out of the watch tend to affect the free end (REGULATOR CIRCLE). Bends in the overcoil when the balance is in the watch tend to push the spring against one of the regulator pins. Isochronal adjusting is closely associated to the FINISHING PROCESSES you studied under hairspring manipulation.

CHECKING ISOCHRONAL RATES

With a timing machine, you can check the rate of a watch at 10 different motions, beginning with 1/2 turn and increasing the motion in steps of 1/8th turn through 1 5/8th turns. Figure 10-12 shows the watch rates of four separate tests, each made with a different shape of the overcoil in the hairspring. See figure 10-13.

The rates obtained from the four tests are shown in figure 10-14, in which the rates of the watch in seconds for 24 hours are plotted vertically and the motion of the balance wheel is plotted horizontally.

In the first test, the isochronal curve is designated CURVE ESTABLISHED BY OVERCOIL AT a. An analysis of the rates from the first to the fourth test does not definitely establish the overcoil as being located exactly at a, b, or c. This test shows that the portion of the overcoil from c to b is too far away from the balance staff, because the rate is slow in the low arcs and faster in the high arcs.

In test number two, the overcoil was bent toward the staff. The isochronal curve for this

Motion of Balance Wheel	Rates in Seconds Obtained in Test Made on			
	Overcoil a	Overcoil b	Overcoil Between b & c	Overcoil c
½ turn	−39	+27	+08	+02
⅝ turn	−32	+20	+05	+02
¾ turn	−24	+14	±00	+01
⅞ turn	−18	+07	−03	±00
1 turn	−15	+03	−05	±00
1⅛ turn	−10	±00	−07	−01
1¼ turn	−07	−01	−09	±00
1⅜ turn	−05	−01	−08	±00
1½ turn	−05	±00	−08	+01
1⅝ turn	−05	+06	−05	+02

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Figure 10-12.—Rates of watches with different shapes in the overcoils of their hairsprings.

test is marked CURVE ESTABLISHED BY OVERCOIL AT b. Here the overcoil is TOO CLOSE to the balance staff, because the rate has reversed itself and is fast in the low arcs of motion and slow in the high arcs.

The third test (overcoil between b and c) shows a slight improvement over the second test, but it indicates that the overcoil is still too close to the balance staff.

Observe in illustration 10-12 that the deviation of the rate of the watch is at a minimum with the overcoil at c, which indicates that this overcoil is located close to the theoretically correct position. In other words, for a watch in good condition, with the regulator circle of its hairspring overcoil centered between the regulator pins (tightly closed), the ideal shape and position of the overcoil resemble the overcoil at c in figure 10-13.

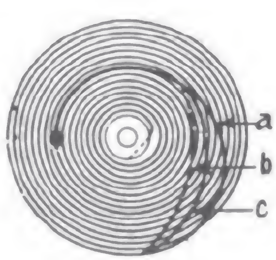

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Figure 10-13.—Position of overcoils for watch rates listed in illustration 10-12.

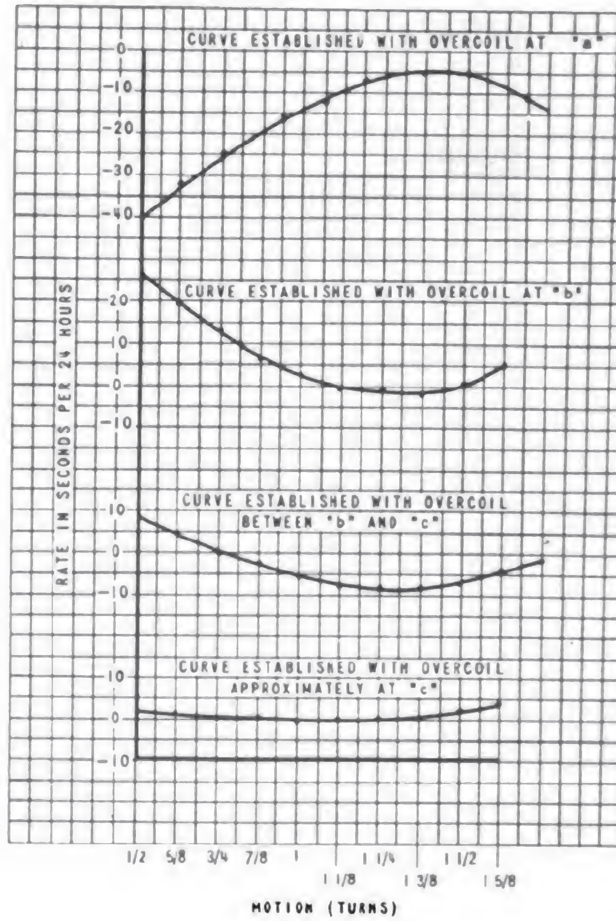

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Figure 10-14.—Chart of watch rates listed in illustration 10-12.

ADJUSTING REGULATOR PINS

Always take into consideration the position of regulator pins when you make corrections for isochronal errors. Some watchmakers advocate that isochronal and position errors can be corrected by opening or closing the regulator pins.

As a general rule, the regulator pins of a watch should be ALMOST closed. An opening of 0.0003 inch is necessary to allow the overcoil to slide freely between the pins; but the maximum opening of the pins should not exceed 0.0006 inch. You can check these measurements with a feeler gage, and observe them with a strong loupe. When a watch is in service, opened regulator pins introduce errors into its rate of operation in a vertical position. If the pins are opened when the overcoil is centered between them, the watch LOSES more and more as it runs down.

If the overcoil bears MORE on one pin than on the other, the watch GAINS more and more as it runs down. Opening the pins may also damage the value of the regulator.

You can test the effect of OPENING and CLOSING the regulator pins of a watch on its isochronal rate in the same manner as explained above for bending the overcoil. Study figure 10-15, which gives the rates of a watch with the regulator pins set in four positions. Note that for the first test the pins were CLOSED TIGHT. While you are studying this illustration, compare the results of the test with the curves drawn on the chart in figure 10-16. The rates of the twelve motions of the balance wheel are shown by the four curves on the chart.

The motion of the balance wheel is plotted horizontally and the RATES are plotted vertically. The time variation is given in minutes and seconds, and each vertical interval on the chart represents 5 seconds per 24 hours.

An analysis of the results of the tests shows that the first test (curve No. 1, pins closed) gave the best isochronal rate. The second test (curve No. 2, pins opened 0.0006 inch) shows that the rate in the lower arcs of motion is relatively slower than the rate in those same arcs with the pins closed. The third test (curve No. 3, pins opened 0.002 inch) shows the effect on the isochronal rate of opening the pins wider. The fourth test (curve No. 4) shows the rate of the watch when the pins are open to contact the spring at the end of a 90° swing. Contact between the hairspring and regulator pins results in an extremely slow rate in the low arcs of motion and a rapidly increasing rate in the high arcs, caused by the shortening of the spring by this contact.

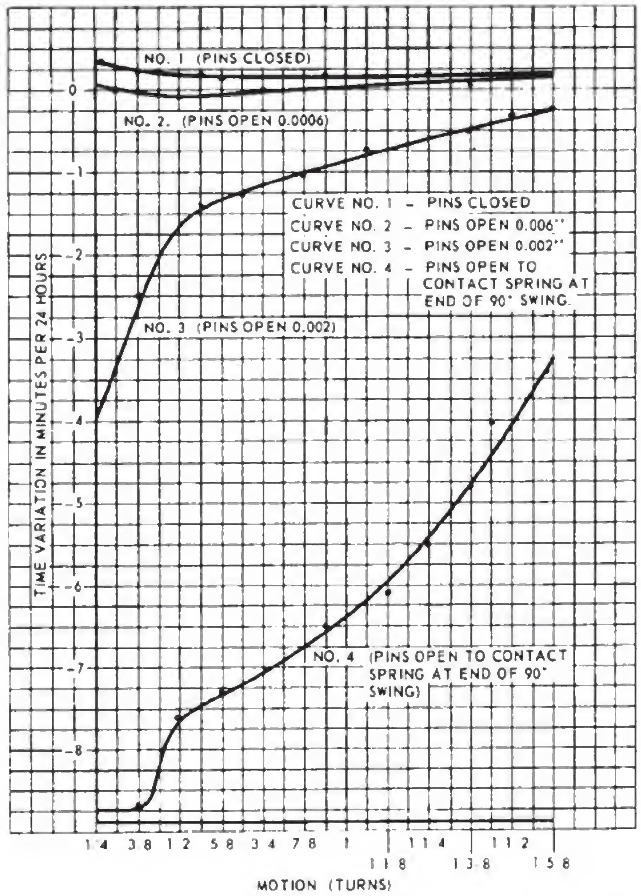

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Figure 10-16.—Chart of watch rates with regulator pins at four different positions.

Motion of Balance Wheel	Rates in Minutes and Seconds Obtained in Tests Made on Overcoil with Regulator Pins			
	(1) Closed Tight	(2) Open 0.0006"	(3) Open 0.002"	In Contact With Hairspring at End of 90° Swing
¼ turn	+00.21	+00.03	−3.54	−8.45
⅜ turn	+00.15	00.00	−2.42	−8.45
½ turn	+00.12	−00.03	−1.36	−7.36
⅝ turn	+00.12	00.00	−1.24	−7.24
¾ turn	+00.12	+00.03	−1.12	−6.54
⅞ turn	+00.12	+00.03	−1.06	−6.27
1 turn	+00.12	+00.05	−0.54	−6.18
1⅛ turn	+00.12	+00.06	−0.42	−6.07
1¼ turn	+00.12	+00.06	−0.36	−5.36
1⅜ turn	+00.12	+00.07	−0.30	−4.48
1½ turn	+00.12	+00.09	−0.24	−3.51
1⅝ turn	+00.12	+00.12	−0.18	−3.15

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Figure 10-15.—Watch rates with regulator pins in four different positions.

If the regulator pins are opened more than the amount for any of the tests just described, the watch has a slower rate, especially in the low arcs of motion. If the points are left WIDE OPEN, the watch loses about 10 minutes per day. It is best to open the regulator pins a very small amount, usually no more than 0.0003 inch.

Modern watches are adjusted for isochronism by manufacturers and no further adjustment is required unless the watch is seriously damaged. When you must adjust a watch for isochronal errors, therefore, follow this rule: KEEP THE PINS ALMOST CLOSED; AND HAVE THE OVERCOIL HIT BOTH PINS WITH EQUAL FORCE. Study figure 10-17, which shows the overcoil between the pins in four different positions.

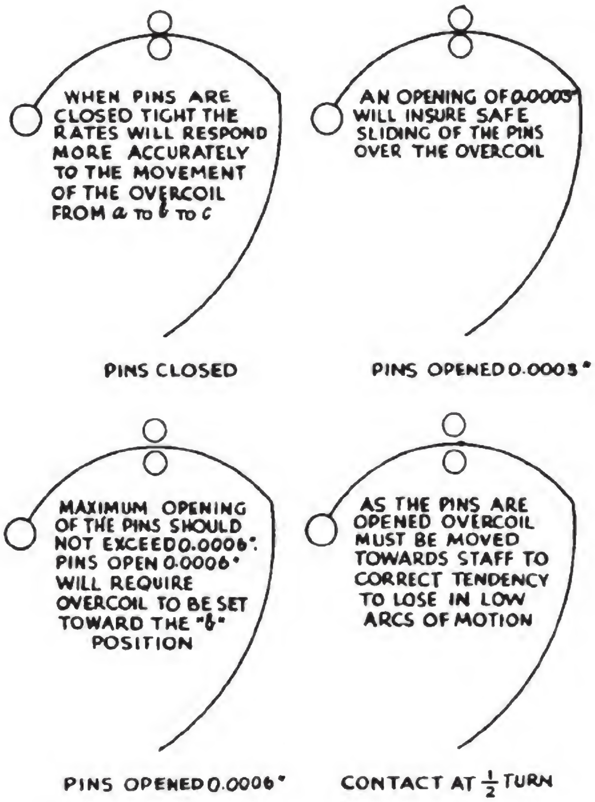

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Figure 10-17.—Overcoil with regulator pins closed and opened (varying amounts).

POSITION ADJUSTMENTS

You will have to adjust for POSITION almost every watch or clock you repair. In order for the balance and hairspring to act as a perfect vibrating system, the balance wheel must be affected only by the energy stored in the hairspring. When there is no friction on the balance pivots and the balance wheel is free to oscillate without influence from an outside force (such as the escapement), the only conditions (omitting temperature) which affect the action of the balance wheel are GRAVITY and MAGNETISM. These conditions, however, may affect the balance of a watch and its timekeeping qualities and make corrective adjustments necessary.

You learned in Instrumentman 3 & 2, NavPers 10193-B, how to demagnetize a watch; and you also learned previously in this chapter about the effect of temperature on the accuracy of a timespiece. Gravity always has some effect on the vibrating of a watch; and if the watch is OUT OF POISE, the force of gravity accentuates this condition and causes appreciable changes in the rate of the watch. These rate changes are particularly noticeable in the vertical positions (12, 6, 9, and 3 UP), the ones generally used for testing.

The names of watch positions used for testing are as follows:

1. Vertical:
   a. 12 UP is PENDANT UP (PU).
   b. 6 UP is PENDANT DOWN (PD).
   c. 9 UP is PENDANT RIGHT (PR).
   d. 3 UP is PENDANT LEFT (PL).

2. Horizontal:
   a. DIAL UP (DU).
   b. DIAL DOWN (DD).

Watches with the best movements are usually adjusted to five positions: PU, PR, PL, DU, and DD. Navy clocks are adjusted to TWO positions: DD and PU.

HORIZONTAL POSITION ADJUSTMENTS

You can use a timing machine to test the running of a watch in the horizontal positions (DU and DD), or you can check it for 24 hours in each position with a timepiece of known accuracy. CORRECT ANY VARIATION between the DIAL UP and DIAL DOWN positions. There are many faults, in fact, which will cause a variation between the running of a watch in the dial up and dial down positions, some of which are:

1. Dirt or thick oil in balance hole jewel(s).
2. Burred or marred balance pivot.
3. End of one balance pivot flat or rough.
4. Balance pivot bent.
5. Ends of balance pivots of different form.
6. Hairspring rubs on balance arm, stud, or regulating pins.
7. Hairspring not level.
8. Overcoil rubs center wheel.
9. Overcoil rubs under balance cock.
10. Balance pivots fit too tight in jewels.
11. One balance pivot has excessive side shake.
12. Escape or pallet pivot bent or damaged.
13. Balance endstone pitted or out of flat.
14. Overcoil rubs outside coil where it curves over the spring.
15. Balance arm touches pallet bridge.
16. Balance screw touches balance bridge.
17. Safety roller rubs plate or jewel setting.
18. Fork rubs impulse roller.
19. Roller jewel too long; rubs on guard pin.
20. Pivot(s) dry.

After you correct all faults that interfere with the accurate running of a watch in the horizontal positions, you must then adjust the arcs of motion in the vertical positions to equal the rate made by the horizontal positions.

VERTICAL POSITION ADJUSTMENTS

The factor which probably has the most effect on the timekeeping of a watch in the vertical positions is poise, which requires detailed consideration at this point.

The purpose of POISING a balance wheel is to distribute the mass (weight) of the wheel evenly around the axis of rotation, so that the effect of the force of gravity is minimized. Weight, by definition, is merely the amount of force exerted on an object by gravity. It is obvious, therefore, that if there is a point on the rim of a balance wheel which is heavier than other points, that point will be pulled down. In short, the balance wheel (without the influence of the hairspring or any other force) rotates until the heaviest part finally settles at the lowest point.

How Gravity Affects Poise Error

The effect of gravity on the poise error of a watch is shown in figure 10-18. Assume that a balance wheel is out-of-poise because of a HEAVY POINT so located that when the balance staff lies in a horizontal plane (watch in PENDANT UP position) and is at rest in the zero position, the center of gravity in the balance wheel is directly below the rotation center (part A, fig. 10-18). If the balance wheel is in motion but moving LESS THAN one turn (less than 180° each side of the neutral (zero) position) when the balance wheel comes to rest at the end of the outward swing, the heavy point will be near the top of the wheel (part B, fig. 10-18). At this point, all energy in the vibrating assembly is potential energy stored in the hairspring.

As the energy in the hairspring is transferred into motion, the force of gravity acting on the heavy point adds additional energy to the balance in the same direction as the energy of the hairspring. This extra energy intensifies the force exerted on the balance wheel and makes the watch run faster.

Now assume that the heavy point on the rim has reached the bottom of its path, when all the energy is stored in the balance wheel—none in the hairspring. As the balance wheel moves past the neutral position, part of this energy is stored in the hairspring and part of it is used in raising the heavy point (part C, fig. 10-18). The balance wheel passes through a shorter arc of motion; that is, it takes less time to complete an oscillation and the watch runs faster.

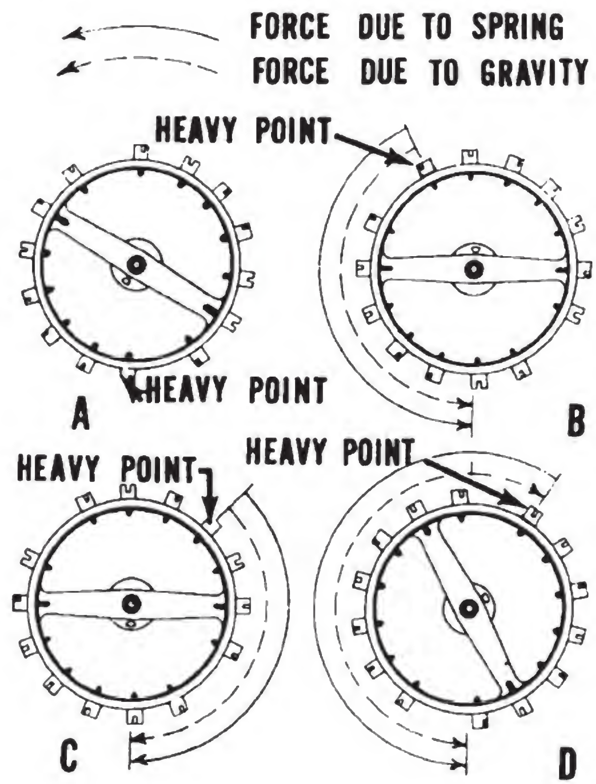

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Figure 10-18.—Forces of hairspring and gravity acting in different arcs of motion.

If the balance wheel is in motion and moving through MORE THAN one turn (over 180° each side of the neutral position), as illustrated in part D of figure 10-18, during the first part of its path (until heavy point is lifted 180°) gravity is opposing the action of the hairspring. During this arc of motion the balance wheel moves more slowly, as if acted upon by a weaker hairspring. After it passes the 180° point, it moves more rapidly down toward the zero point, because the effect of the hairspring is strengthened by the energy added by the HEAVY point. In other words, the effect of gravity on the heavy point causes a slower motion in the first portion of the path and a faster motion in the second part.

Experience has shown that a swing of about 1 1/4 turns of a balance wheel is the ideal motion, because small out-of-poise errors are

neutralized at this point. Few watches maintain this motion for a 24 hour period, however, so it is necessary to poise watches. When you are locating the theoretical heavy point of a balance during the poising operation, make certain that the watch is less than HALF WOUND. You already learned that you can redistribute the weight on the rim of a balance wheel by undercutting screws, moving screws, or adding weight to screws with washers.

Tests for Position Errors

An out-of-poise watch with a heavy point in the position of part A of figure 10-18 was tested for position errors (changes of rate under varying arcs of motion). The rates of motion from 240° to 444° were taken in successive steps at two positions, 12 UP and 6 UP. The results of this test with the watch running at 11 different arcs of motion are listed in figure 10-19.

How Heavy Point Affects Watch Rate

When a watch is in the PENDANT UP position and has a heavy point at the BOTTOM of its balance wheel, it is apparent that:

1. If the motion is less than 444°, the rate is faster in the PENDANT UP position than in the PENDANT DOWN position.
2. If the motion is over 444°, the rate is faster in the PENDANT UP position than in the PENDANT DOWN position.

In other words, when the force of the hairspring and the effect of gravity on the heavy point both act in the SAME direction, the rate of the watch is fast. When the effect of gravity on the heavy point is in the OPPOSITE direction from the force of the spring, the rate of the watch is slow.

From the previous discussion, it appears evident that when the HEAVY point is at right angles to the PU position the effect of gravity on this point does not affect the rate in the PU or in the PD POSITIONS, for the PL and PR positions are then on the axis of greatest vibration. To determine the rate variations of a watch in the various vertical positions, we must measure the rate in each position. The results of such measurements are shown in figure 10-20.

The measurments listed in figure 10-20 were taken with a timing machine for all 12 positions. The arcs of motion used for the test were 1 1/4 turns, 1 1/4 minus turns, and 7/8 turn. A comparison of the rates measured with those of the opposite points UP gives the results tabulated in the VARIATION column. For example, at the PU position the watch rate is 6 seconds slow (-06) per 24 hours, but at the PD position the rate is 1 second slow (-01) per 24 hours. The watch tested, therefore, is running 5 seconds slower each day in the PU position than in the PD position, giving a variation in rate of 5 seconds. In the PR position the rate of the watch is minus 30 seconds per 24 hours, and in the PL position, the rate is plus 39 seconds, giving a

	Rate (in seconds) at Arc of—										
Position	270°	290°	330°	350°	360°	380°	400°	420°	438°	442°	444°
12 UP	+ 57.0	+ 46.0	+ 37.0	+33.0	+12.6	−02.8	−01.5	−08.8	−15.5	−17.8	−17.4
6 UP	− 74.4	− 71.6	− 64.0	−59.0	−44.2	−34.6	−27.0	−23.8	−18.0	−18.8	−17.4
Difference	+131.4	+117.6	+101.0	+92.0	−56.8	+31.8	+25.5	+15.0	+02.5	+01.0	00

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Figure 10-19.—Differences between watch rates for varying arcs of motion.

WATCH RATES: RATES AND RATE VARIATION (Seconds Per 24 Hours) AT VERTICAL POSITIONS FOR DIFFERENT ARCS OF MOTION

Position (up)	1¼ Turn (450°)		1¼ Minus Turn (444°)		7/8 Turn (315°)	
	Rate (seconds)	Variation (seconds)	Rate (seconds)	Variation (seconds)	Rate (seconds)	Variation (seconds)
12	−06	−05	0	0	+02	+01
1	+21	+39	+01	+01.5	−13	−25
2	+35	+61	+01.5	+02.5	−21	−36
3	+39	+69	+01.5	+03.5	−24	−42
4	+34	+61	+01	+03	−21	−36
5	+22	+41	+00.5	+02.5	−13	−26
6	−01	+05	0	0	+01	−01
7	−18	−39	−00.5	−01.5	+12	+25
8	−26	−61	−01	−02.5	+15	+36
9	−30	−69	−02	−03.5	+18	+42
10	−27	−61	−02	−03	+15	+36
11	−19	−41	−02	−02.5	+13	+26
12	−06	−05	0	0	02	+01

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Figure 10-20.—Watch rates (and rate variation) at vertical positions for different arcs of motion.

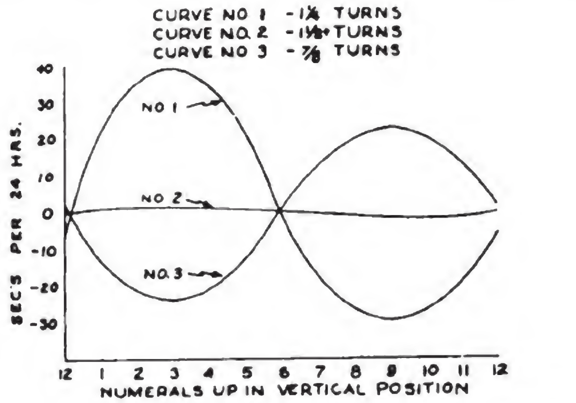

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Figure 10-21.—Chart of watch rate variations in different vertical positions (three arcs of motion).

variation in rate between the PL and PR positions of plus 39 seconds (variation of minus 69).

Figure 10-21 depicts graphically the rate variation of the watch tested in different vertical positions (arcs of motion). Observe the amount of turn for each curve. Curve No. 1 shows that the two positions which have the greatest variation in rate are PL and PR. The distances of the extreme points on curves No. 1 and No. 3 from the horizontal axis indicate that the watch is out-of-poise. Curve No. 3, representing the results of the test after the motion of the balance wheel was reduced from 1 1/4 turns to 7/8 turn, shows that with this change in the arc of motion all the fast rates have changed toward SLOW and the slow ones have changed toward FAST.

The variations in rate of a watch in all vertical positions (with different arcs of motion) can always be observed by plotting a chart of the type shown in figure 10-21. In practice, however, the quickest way to locate a poising error is to use a poising tool.

Correction of Heavy Point Poise Error

If you use rate-variation curves to find the exact location of the HEAVY POINT on a balance wheel, note first the positions which show the faster rate. Curve No. 3 in figure 10-21, for example, shows the greatest variation in rate at the PR position. This indicates, therefore, that the HEAVY POINT is at PL. To correct this poise error, proceed as follows:

1. Let the mainspring down.
2. Place the watch movement in a vertical position, PU, on the work bench, with the balance wheel facing front.
3. Make a drawing of the balance wheel, showing LINE OF CENTERS, location of balance arms, and the roller jewel. Indicate the position of the heavy point at the bottom of the balance wheel.
4. Wind the mainspring slightly, enough to keep the balance wheel moving at 1/2 turn. This causes the heavy point to move 90° to the left and to the right.
5. Wind the mainspring a little tighter, enough to increase the arc of motion to the extent necessary to raise the heavy point to a 7/8 turn; then raise the heavy point (by winding) to 1 turn. Wind the mainspring tighter. Increase the motion of the balance gradually until it reaches its maximum swing (444°). When the heavy point reaches a point of 42° (444 minus 360 equals 84, and 84 divided by 2 equals 42) beyond the vertical axis, it arrives at a point where the gaining effect caused by gravity balances the losing effect present up to the vertical line.
6. Remove the balance wheel and take off the collet and hairspring.
7. Put the balance wheel in poising calipers or a poising tool. When you do this, gravity pulls the heavy point to the bottom.

After you poise the balance wheel, test the rate of the watch in vertical positions with a timing machine. If the rates of the watch for the different arcs of motion are as illustrated by the curves in figure 10-22, you have satisfactorily adjusted the watch for position.

Another Method of Testing and Adjusting

Another way to test a watch for vertical position errors is to check it against an accurate watch over a 24-hour period in the DIAL UP, PENDANT UP, and PENDANT DOWN positions. After completion of the three-position test, the recorded rates may be as follows: dial up, 6 seconds fast for 24 hours; pendant up, 4 seconds slow for 24 hours; and pendant down, 26 seconds slow for 24 hours. This rate shows that with the pendant up it is 10 seconds slower than with the dial up; and with the pendant down it is 32 seconds slower than with the dial up. The mean for this rate is 21 seconds, the amount the SHORT ARCS ARE SLOW. The hairspring coils do not open and close equally in both vertical positions because of an improperly formed overcoil which does not hold the hairspring concentrically. To make correction, reform the overcoil until the rates of the vertical positions are equal. The arcs of motion are then equal.

After completing the three-position test, the rates of the watch may be: dial up, 3 seconds FAST for 24 hours; pendant up, 11 seconds FAST for 24 hours; and pendant down, 5 seconds SLOW for 24 hours. This shows that with the pendant UP it is 8 seconds faster than with dial UP; and with the pendant DOWN, it is 8 seconds slower than with the dial UP. The mean of the two vertical positions is equal to that of the horizontal. The difference between pendant UP and pendant DOWN shows a slight error in poise. The losing rate (pendant down position) signifies a heavy point at the top of the balance when it is running in that position. To correct for the heavy point, turn the meantime screw of the pendant down position a quarter turn clockwise. If this screw is too close to the rim, turn the meantime screw of the pendant up position a quarter turn counter-clockwise.

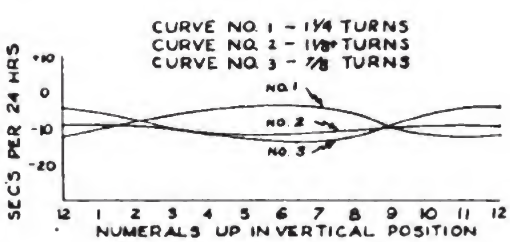

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Figure 10-22.—Chart of watch rate variations (poise errors corrected).

HORIZONTAL VERSUS VERTICAL POSITION RATE

A watch perfectly adjusted in the horizontal position always runs a little slow in the vertical positions, because of friction from the two balance pivots running on the side of each hole jewel and the increased effect of gravity on the hairspring. The difference in rate is usually about 15 seconds. The vertical rate can be made faster by closing the regulator pins, thereby decreasing the effect produced by a longer hairspring. Do NOT allow the vertical motion of a watch to fall below one full turn at the end of 24 hours. As indicated previously in this chapter, an arc of motion of 1 1/4 turns during the day for the vertical positions is desirable.

OTHER POSITION-ADJUSTING METHODS

Some other methods for adjusting the rate of a watch (exclusive of corrections for poise error) are:

1. Replacing a worn or damaged balance staff.
2. Cleaning and oiling balance staff jewels.
3. Moving regulator pins IN or OUT.
4. Removing obstruction to the FREE movement of the hairspring.
5. Using a different angle for pinning the hairspring in the collet.
6. Changing the shape of the overcoil.

As you doubtless have observed, some of the above methods for adjusting the rate of a watch are a restatement of what you have previously learned in this text. Always use your total knowledge and experience, therefore, when you select a method(s) for adjusting rate. In one instance, a single method is adequate; in other instances, a combination of methods may be required to properly regulate the rate of a watch.

PUTTING A WATCH IN BEAT

A watch is in beat when the hairspring is unstressed and the roller jewel is midway between

the two banking pins (fig. 10-23). A watch is out of beat when the hairspring is attached to the balance staff in such a position that (when unstressed) it holds the roller jewel a number of degrees away from the line of centers.

To determine whether a watch is in beat, hold it in the dial down (DD) position and use a beat tool to stop the balance; that is, try to get an escape wheel tooth to stay locked on either the R or the L stone of the pallet. You can best do this by allowing a balance screw to hit against the beat tool. If you cannot stop the motion of the balance wheel by this action, the watch is in beat.

If you can stop the balance by the action just described, test for the direction of the starting push. You can do this by carefully bringing a beat tool into contact with a balance screw. When a slight touch or push releases the escapement and starts the balance in motion, the direction of the balance is the correct direction of the starting push. If you had put the beat tool on the opposite side of the same screw and pushed, you would have applied the push in the WRONG direction and the escapement would not have been released. It is the STARTING PUSH which causes the roller jewel to hit against the fork slot of the pallet which, in turn, unlocks the tooth of the escape wheel. You can therefore decide in this manner on which side of the line of centers the roller jewel is when you arrest the motion of the balance wheel. When the hairspring is unstressed, the roller jewel lies on this side.

To correct the error just explained and bring the watch into beat, use one of the following methods:

1. Hold the collet by inserting a beat tool into its slot. See figure 10-24. Then turn the balance wheel in the same direction as the starting push.

2. Hold the balance wheel still and use a beat tool to move the collet in the opposite direction of the starting push.

Only through experience will you learn HOW MUCH TO MOVE THE COLLET on the balance staff in order to put a watch in beat.

Figure 10-24 shows a balance wheel which was stopped with a beat tool, with the pallet locked on the L stone. The roller jewel, as indicated, is positioned to the left of the line of centers. This watch is OUT OF BEAT, and the error can be corrected by one of the two aforementioned

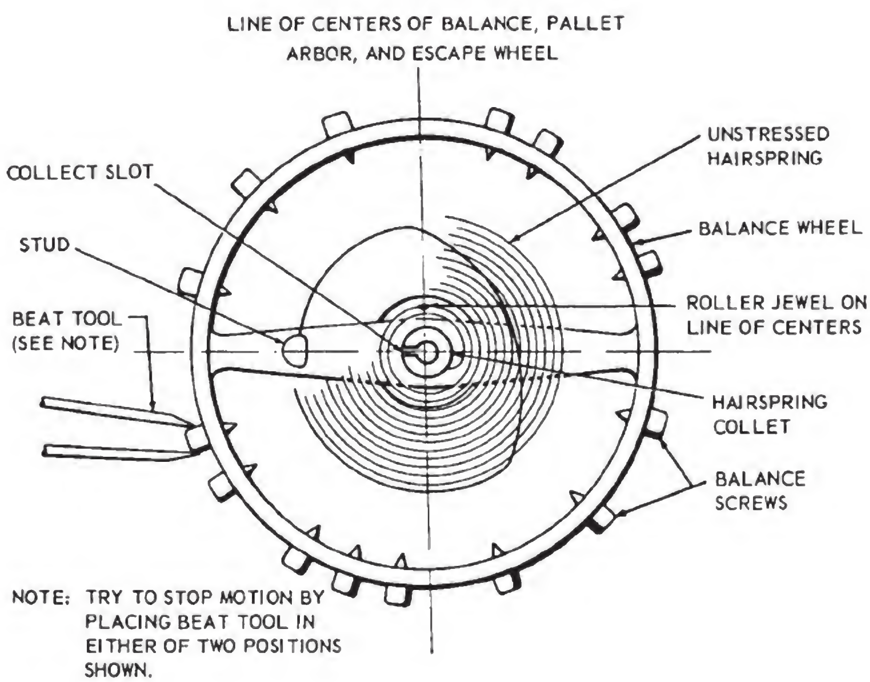

Figure 10-23.—Position of roller jewel (jewel pin) of a watch in beat.

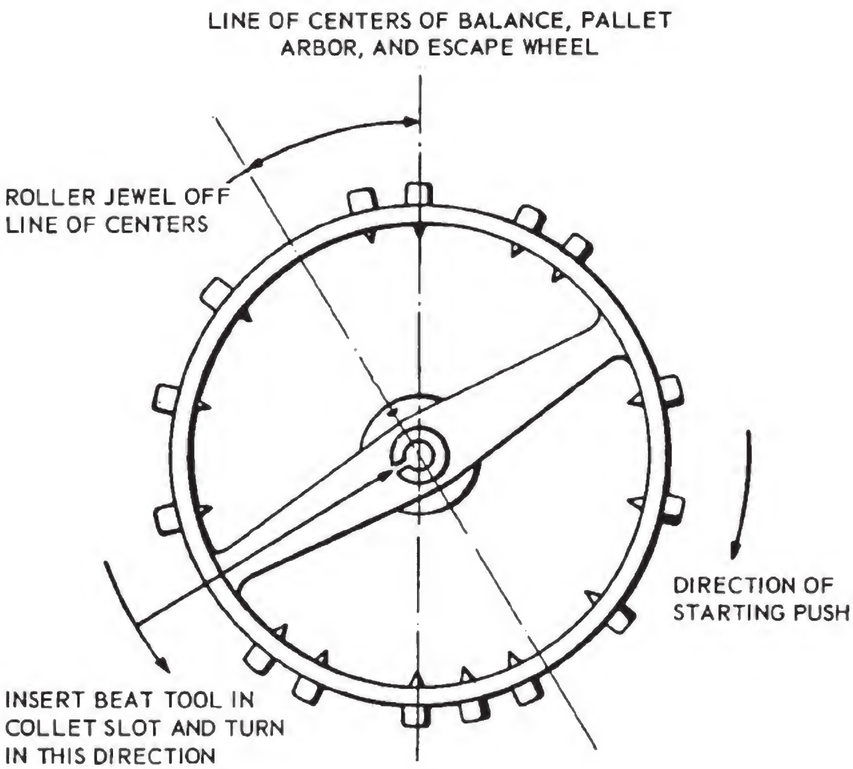

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Figure 10-24.—Using a beat tool to put a watch in beat (roller jewel left of line of centers).

methods. Either method so shifts the collet that the roller jewel is on the line of centers.

Study next figure 10-25, which shows a balance wheel stopped, with the pallet locked on the receiving (R) stone. In this case, the roller jewel is positioned to the right of the line of centers (balance nearest you; escape wheel fartherest away). This indicates that the WATCH IS OUT OF BEAT, and that the roller jewel will be to the right of the line of centers when the hairspring is unstressed. By using one of the previously mentioned methods, you can shift the collet sufficiently with a beat tool to bring the roller jewel to the line of centers, thereby putting the watch in beat.

When you cannot reach the collet when the balance wheel is in the watch, to prevent damage to pivots or the hairspring, remove the balance cock and balance wheel before you attempt to shift the hairspring collet.

Illustration 10-26 shows a balance cock on a tapered piece of pegwood or brass inserted in a hole of a bench anvil. With the balance cock and suspended balance wheel in this position, hold the balance wheel with the left hand and insert a beat tool held in the right hand down through the coils of the spring and into the collet slot. Then turn the collet in the direction necessary to put the watch in beat (clockwise when a counterclockwise movement of the balance wheel is desired, and vice versa).

FINAL REGULATIONS

Final regulations of a watch are the last minute regulations made by moving the regulator toward FAST or SLOW, as required. A watch may keep perfect time in the shop but fail to keep good time when in use. This may be caused by changes in temperature, irregular winding, jolts, or other adverse conditions. For these reasons, final regulations must be given a watch to meet the conditions under which it is (or will be) used.

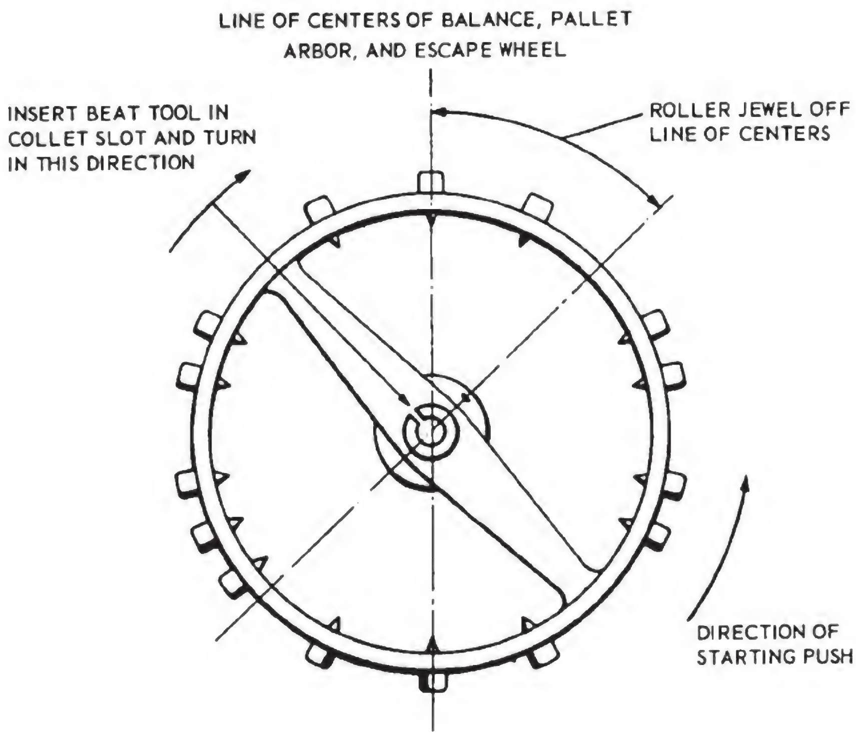

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Figure 10-25.—Using a beat tool to put a watch in beat (roller jewel right of line of centers).

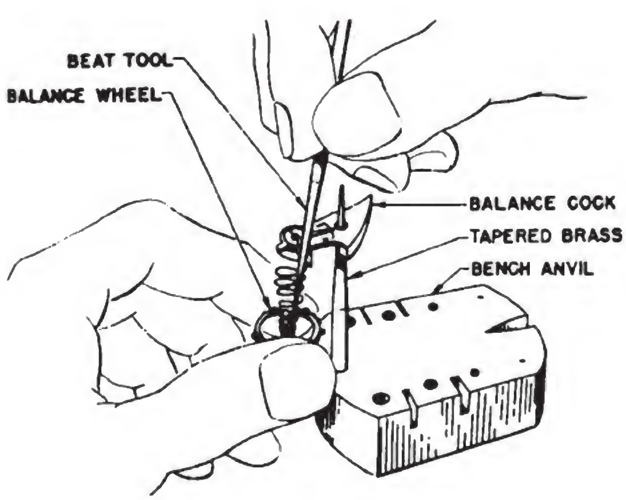

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Figure 10-26.—Turning hairspring collet with beat tool (hairspring fastened to balance cock).

If a watch fails to keep good time after you make all the adjustments possible by moving the regulator, a weak mainspring may be causing trouble, or adjustments on the balance wheel are necessary; that is, adjustments on the meantime screws, or moving the positions of these screws.

A newly-overhauled watch may gain or lose several minutes per day, but a complete turn IN or OUT of opposite pairs of meantime screws (sometimes considerably less than a full turn) is sufficient to make the watch keep accurate time.

CLOCK TESTING AND ADJUSTING

The following discussion is the recommended procedure for adjusting a clock with a timing machine, and also for giving it a performance test. Proceed as follows:

1. Set the clock regulator to the exact center position between F (fast) and S (slow).

2. Clamp the clock movement on the timing machine (fig. 10-1). NOTE: ALWAYS TIME AND

TEST a clock movement in its normal operating position—vertical position with the 12 (or 24) numeral up.

3. Following the manufacturer's instructions, operate the timing machine and note the 24-hour error indicated on the chart recording.

4. Adjust the two meantime (timing) screws to correct the error in rate, as illustrated in figure 10-27. (Meantime screws have smaller heads than the other screws and are located close to the ends of the balance arms.) One complete turn of the timing screws is equivalent to about 100 seconds per day. If the chart shows the clock is gaining time, turn the timing screws OUT; if the recording shows the clock is losing time, turn the timing screws IN. Turn both timing screws the same amount in the same direction. If you cannot bring the clock into correct time by turning the timing screws, make necessary adjustments in the weight of the balance wheel.

5. If the clock is losing time, undercut any two opposite balance screws (or file out the slots) by exactly the same amount. If the clock is gaining time, add timing washers (equal weight) to two opposite balance screws.

6. Place the clock in the timing machine again and adjust the timing screws until the chart recording shows neither gain nor loss of time.

When you have the clock keeping perfect time, give it a performance test to make certain that the escapement adjustments were adequate, and to check the accuracy of the timing screw adjustments.

Make the performance test with the clock in a vertical position and at normal room temperature (68° to 72° F). Check the clock against a standard-frequency comparing clock, observing the daily error of the clock. Make notations of dial errors of successive readings. If these dial errors are recorded daily, the rate is indicated by the time GAINED or LOST per day. If observations are unavoidably checked more than one day apart, reduce the rate to a 24-hour basis by dividing the difference in dial errors by the number of days involved. See figure 10-28. Unusual conditions should be noted in the REMARKS COLUMN of this chart, in order that they may be taken into consideration when you determine whether the clock has passed its test.

Other factors besides the daily rate must also be taken into consideration when you try to prove the timekeeping qualities of a clock. If a clock gains exactly 15 seconds per day, it is an excellent timekeeper, because this error can be corrected by slightly slowing down the clock with the regulator. On the other hand, if a clock gains 5 seconds one day and loses 5 seconds the NEXT day, it is NOT AS ACCURATE as the first clock; because the error of this clock CANNOT BE CORRECTED by moving the regulator. Take this factor into account by comparing the daily rate error of the clock with the weekly error divided by 7. A limit must also be placed upon the allowable difference between the two errors.

Refer again to the performance chart. The overall weekly dial error (last entry in column 2 minus the first entry in column 2) must be NO MORE THAN 2 minutes for mechanical

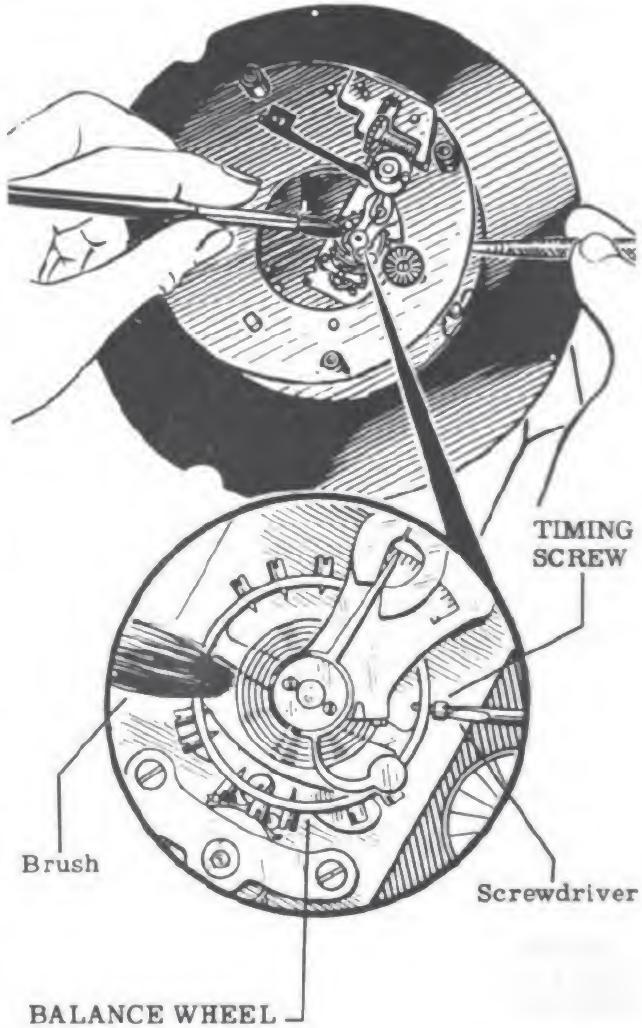

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Figure 10-27.—Adjusting two meantime screws on a clock balance wheel.

1 DATE	2 DIAL ERROR + = Fast - = Slow		3 DAILY RATE (Daily Error)	4 AVERAGE (Daily Error)	5 DEVIATION OF DAILY ERROR (col 3-col 4)	REMARKS
	Min.	Sec.	Sec.	Sec.	Sec.	
July 1951						
13	-0	03				Started and set 3 seconds slow
14	-0	10	-7	-10	+3	
15	-0	18	-8	-10	+2	
16	X	X	X	X	X	Not checked
17	-0	37	* -10	-10	0	* Two-day average
18	-0	49	-12	-10	-2	
19	-1	1	-12	-10	-2	
20	-1	15	-14	-10	-4	

Weekly error Jul 14-20 = 1 min 15 sec -03 sec = 1 min 12 sec = 72 sec. Average daily error = 10-2/7 sec = 10 sec.

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Figure 10-28.—Weekly performance chart of a clock tested with a timing machine.

clocks, and NO MORE THAN 2 1/2 minutes for boat and deck clocks, for any of the 3 weeks of performance testing. NOTE: Results of one week's testing of clocks are helpful; but if possible, extend the tests over a three weeks' period.

No deviation of daily error in one of the 3 weeks of testing in column 5 of the test chart may be more than ±10 seconds for mechanical clocks and not more than ±15 seconds for boat and deck clocks.

CHAPTER 11

MANUFACTURING

The term MANUFACTURING, as used in this chapter, applies to all instrument parts which you may be required to make in a Navy instrument shop. As a general rule, you will be able to get replacement parts from stock; but in some locations, or during emergency conditions, you may have no alternative but to make new parts for instruments. For this reason, and in order to satisfy the qualifications for advancement in rating, you need to understand the procedures for manufacturing various instrument parts.

Before you can qualify for advancement to Instrumentman 1, you must be able to prepare a sketch of instrument parts, showing dimensional and material specifications; and you must know how to make such parts as gravers, boring tools, pivot drills and plug gages, screwdriver bits, tapered pins, links, gage bushings, and bridges.

In order to qualify for advancement to a Chief Instrumentman, you must be able to satisfy all the requirements of an Instrumentman 1 and also understand the following:

1. Materials used and steps involved in making watch stems, watch and clock thread taps, and watch shafts and balance staffs.
2. Techniques and tools used in manufacturing jewel settings.
3. Methods and materials used in making pressure gage pinion staffs, arbors, bearing screws, and tachometer backplates.

You already learned in Instrumentman 3 & 2, NavPers 10193-B, the materials to use and the procedures to follow in making drill and tap gages, spring hooks, and screwdrivers. In this chapter you will learn how to make a watch balance staff, a watch stem, barrel arbors, instrument bushings, jewel mountings, and some other instrument parts. If you know how to prepare sketches for and be able to make some instrument parts, you will in time learn how to make most of the other parts which require replacement. Bear in mind, however, that you will attain proficiency in making these parts ONLY through experience in instrument shops.

WATCH BALANCE STAFF

The tools you need for making a watch balance staff include the following: alcohol lamp, millimeter micrometer, jeweler's lathe, gravers, No. 30 chuck, polishing block, pin vise, bellmetal slip, iron metal slip, and cement brasses.

MEASUREMENTS FOR NEW STAFF

If you have an old balance staff of the same dimensions as the one you need to make, use it as a sample. There may be occasions, however, when you will not have another staff which can be used as a sample. When this is true, you are compelled to compute the measurements for your new balance staff.

To get the measurements for a new balance staff, proceed as follows:

1. Remove the upper and lower cap jewels of the balance cock and screw the balance cock in position on the pillar plate. NOTE: The balance cock and pillar plate must be parallel. If the balance cock is bent, straighten it before you take any measurements.
2. Measure the distance from the top of the upper hole jewel to the bottom of the lower hole jewel and allow .01 mm extra for the protrusion of the balance pivots.
3. To get the position of the balance wheel, measure from the lower balance hole jewel to the top of the pallet bridge. Add to this measurement the freedom necessary between the balance wheel and the pallet bridge. Special consideration must be given to the correct location of the balance wheel in order to allow for the hairspring and collet.
4. Measure from the lower balance hole jewel to the top of the fork and add the thickness of the impulse roller to get the correct location of the roller seat. Bear in mind that the fork and guard pin are parallel with the pillar plate and that the end of the guard pin must coincide with the center of the safety roller.

5. Get the length of the collet shoulder by measuring the height of the hairspring collet. The other part of the staff is for the upper and lower balance cones and pivots.

6. To determine the diameter of the collet shoulder, select a brass wire with a diameter a little larger than the hole in the collet and chuck the wire in the lathe. Put enough taper on the wire to make the collet fit friction-tight on it. The position of the collet on the large side of the tapered wire determines the diameter of the collet shoulder.

7. Get the diameter of the roller shoulder by doing the following: Turn the roller shoulder on a slight taper until the roller table fits on the small end of the taper. Use an iron metal slip charged with oilstone powder and oil to grind the roller shoulder enough to get the roller table to almost fit up to the roller seat. The space between the roller seat and the roller table MUST NOT EXCEED DOUBLE THICKNESS of the impulse roller. Use pithwood to clean off all traces of oilstone. Polish the roller shoulder with a bellmetal slip charged with diamantine.

METHODS OF TURNING

Two methods are generally used for turning a watch balance staff and both are described in some detail in this section. The first method is perhaps used most frequently, but you will learn through experience which one you prefer.

Method No. 1

Select a piece of steel wire stock slightly larger than the greatest diameter of the staff you are making (dimensions on your sketch). Then put the sample balance staff over your piece of steel wire stock, as illustrated in figure 11-1. Next, cut from the wire a piece 0.1 mm longer than your sample staff and harden and temper it, as explained in Instrumentman 3 & 2, NavPers 10193-B.

NOTE: While you are making the balance staff, use a micrometer frequently to check the diameter, to make certain that you cut off JUST ENOUGH metal. Always leave enough metal on the part you are making to allow for polishing and finishing.

Now select a No. 30 chuck, which correctly fits the blank, and chuck the blank in the lathe (fig. 11-2), with enough of it projecting from the chuck to enable you to turn the hub of the staff.

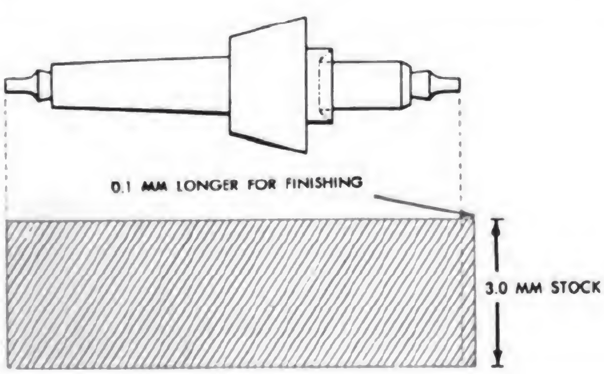

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Figure 11-1.—Sample balance staff and wire stock for a new balance staff.

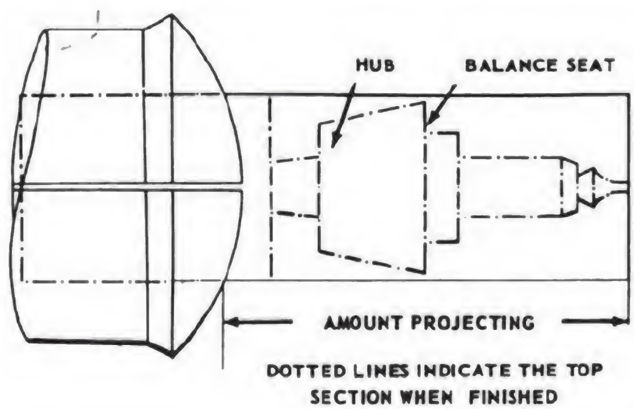

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Figure 11-2.—Steel wire for new balance staff chucked in a lathe for turning the hub.

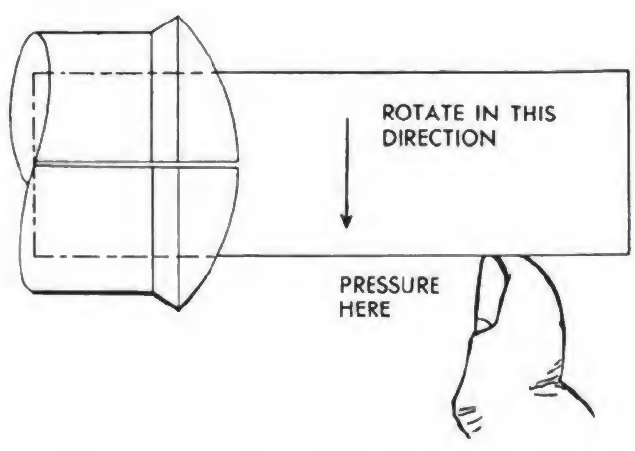

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Figure 11-3.—Truing stock chucked in a lathe for making a balance staff.

Tighten the chuck just enough to prevent your blank from falling out when the lathe is rotating, so that you can true it with your thumb as it rotates. Study the procedure for doing this in illustration 11-3. Then tighten the chuck fully and examine it with a loupe for trueness.

Continue by clamping the roller shoulder of the sample staff in a pin vise (fig. 11-4) and placing the sample staff parallel with the blank, so that you can mark the balance seat with a graver. Study figure 11-4, noting particularly the position of the balance seat of the sample staff and the location of your mark on the blank.

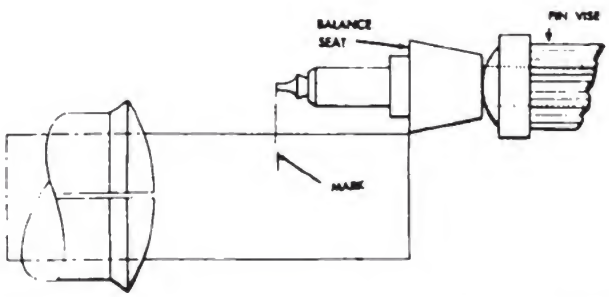

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Figure 11-4.—Procedure for marking the balance seat of a new staff.

Now turn on the lathe and start turning the staff with a sharp graver, as shown in figure 11-5. Observe the position of the T-rest and the direction of the cut. Use the point of the graver first to true the steel blank and then use the FULL CUTTING EDGE. To avoid ridges,

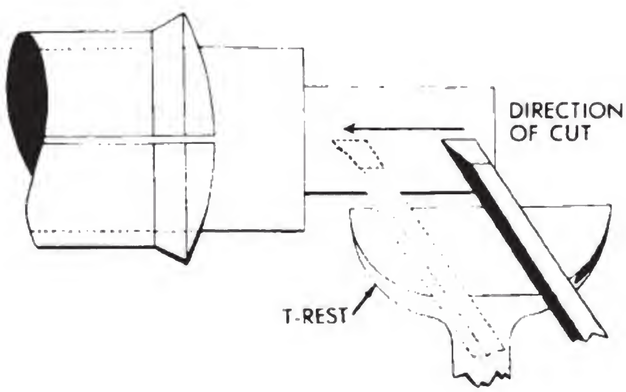

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Figure 11-5.—Turning a steel blank for a balance staff with a graver.

apply even pressure to the graver and then move it back and forth on the blank.

Use care TO AVOID making the balance shoulder TOO SMALL. Check the diameter with the micrometer.

Turn the stock (shoulder) on a slight taper until the small end fits in the balance wheel hole. Study figure 11-6. Then gradually straighten the stock (taper of balance shoulder) until the balance wheel fits perfectly against the balance seat, as illustrated in figure 11-7. If the fit is

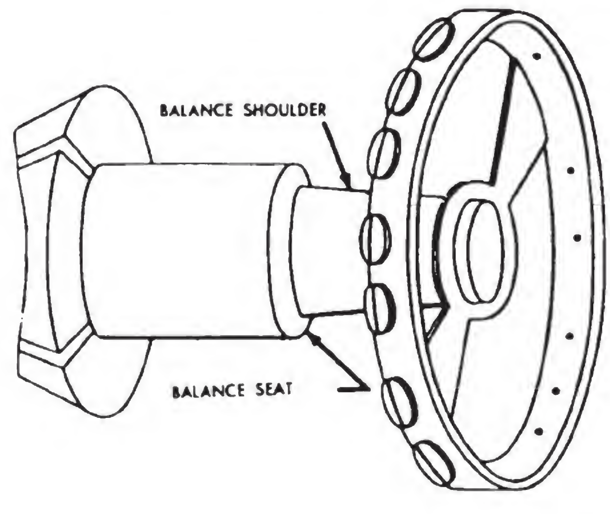

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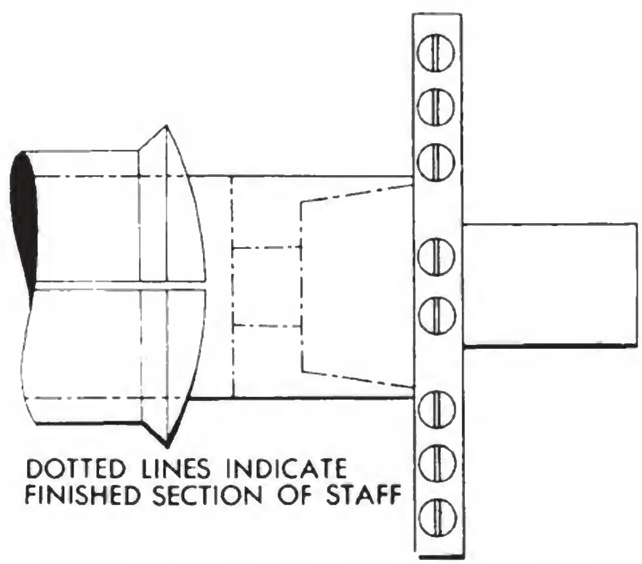
Figure 11-6.—Turning the balance shoulder of a new balance staff.



91.289X
Figure 11-7.—Balance wheel fitted on the taper of a new balance staff shoulder.

too loose, it will cause the balance wheel to be out-of-round when staked; if the fit is TOO TIGHT, it will stretch the balance wheel hole and PERHAPS DISTORT the balance wheel during staking.

Next, turn the hub of the staff .02 mm larger in diameter than the hub of your sample, as shown in figure 11-8.

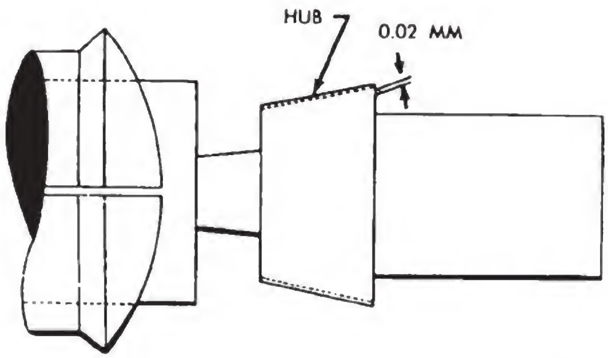


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Figure 11-8.—Turning the hub of a new balance staff.

Position the balance wheel against the balance seat on the stock and mark the stock with the graver, approximately 0.1 mm from the balance arms. This measurement determines the length of the balance shoulder. Study parts A and B of figure 11-9.

Now start at the mark you made with the graver on the stock and turn the collet shoulder until the diameter is 0.02 mm thicker than the sample (fig. 11-10).

Use a sharp, pointed graver in the manner shown in figure 11-11 to do the undercutting

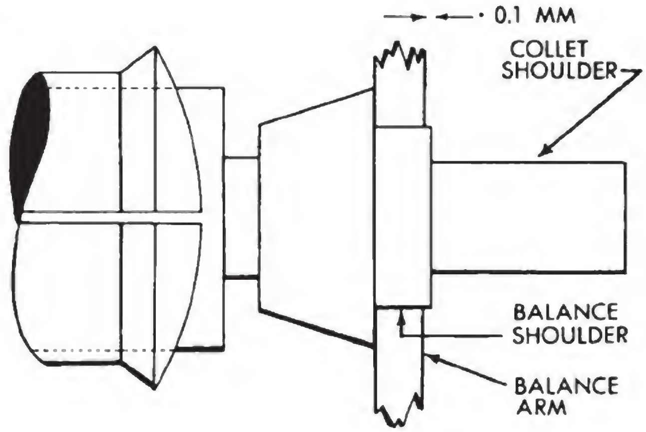

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Figure 11-10.—Turning the collet shoulder.

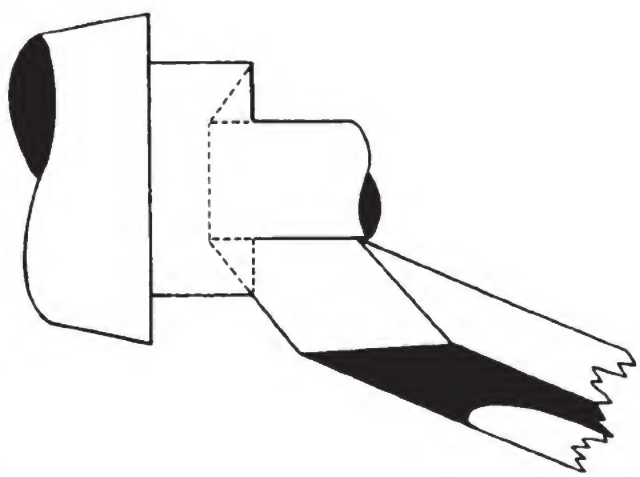

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Figure 11-11.—Undercutting a new balance staff for staking.

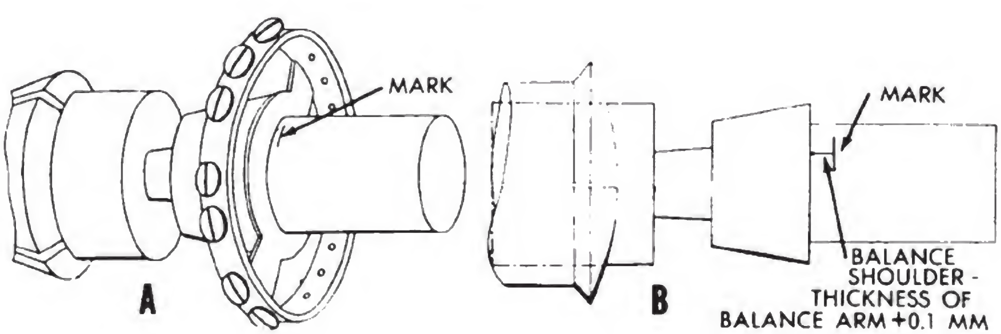

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Figure 11-9.—Marking the length of the balance shoulder.

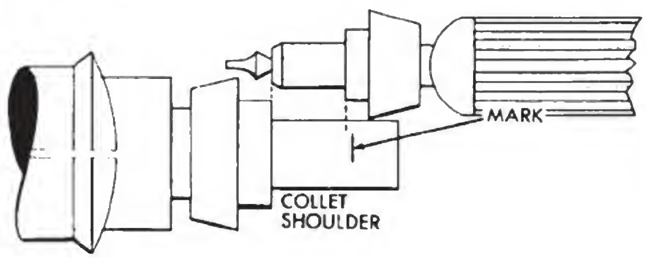

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Figure 11-12.—Marking the length of the collet shoulder.

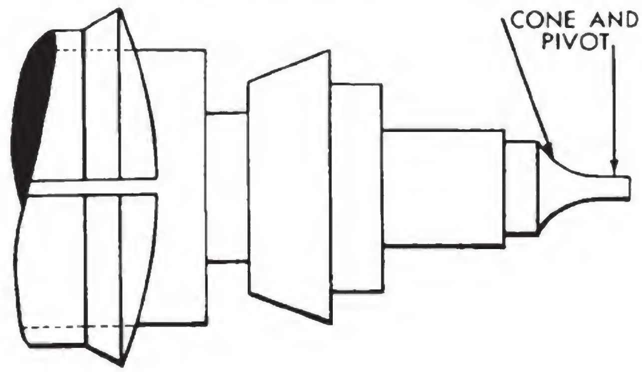

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Figure 11-13.—Turning the upper cone and pivot of a new balance staff.

necessary for staking the balance wheel to the staff. Then place the sample balance staff parallel with the blank, so that you can use a graver to lay off the length of the collet shoulder on the blank, as illustrated in figure 11-12.

From the mark you just made on the collet shoulder, turn the upper cone and pivot of the staff. See illustration 11-13. As you turn the pivot, check it frequently with a balance hole jewel of correct size. Continue turning until the pivot starts to fit in the jewel. CAUTION: Stop cutting while there is sufficient metal left for grinding and polishing.

At this point, select a graver with a rounder point (part A, fig. 11-14) and turn the pivot until it is approximately 2/3 cone and 1/3 pivot, as illustrated in part B of figure 11-14.

Next, select a sharp, pointed graver and turn a back taper on the cone. Study part A of figure 11-15. Note the direction of this cut. CAUTION: To prevent breakage of the fine point on the graver, use much care in making this cut. Continue your turning by putting a bevel on the upper end of the collet shoulder, as shown in part B of figure 11-15.

Now use an iron slip (part A, fig. 11-16) charged with oilstone powder to grind the hub

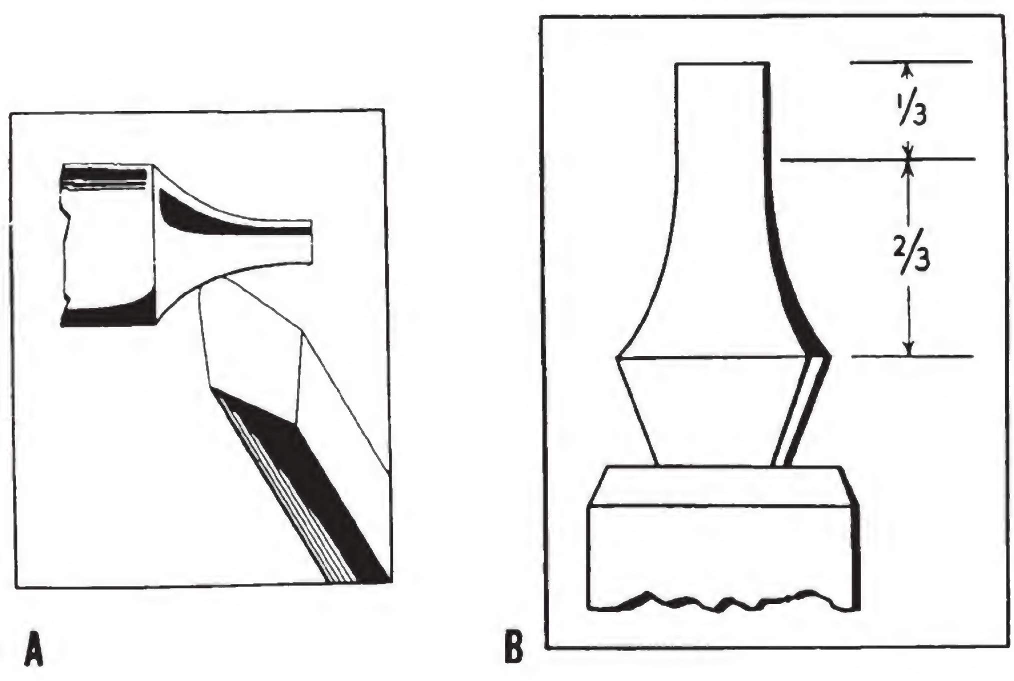

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Figure 11-14.—Turning the cone on the pivot.

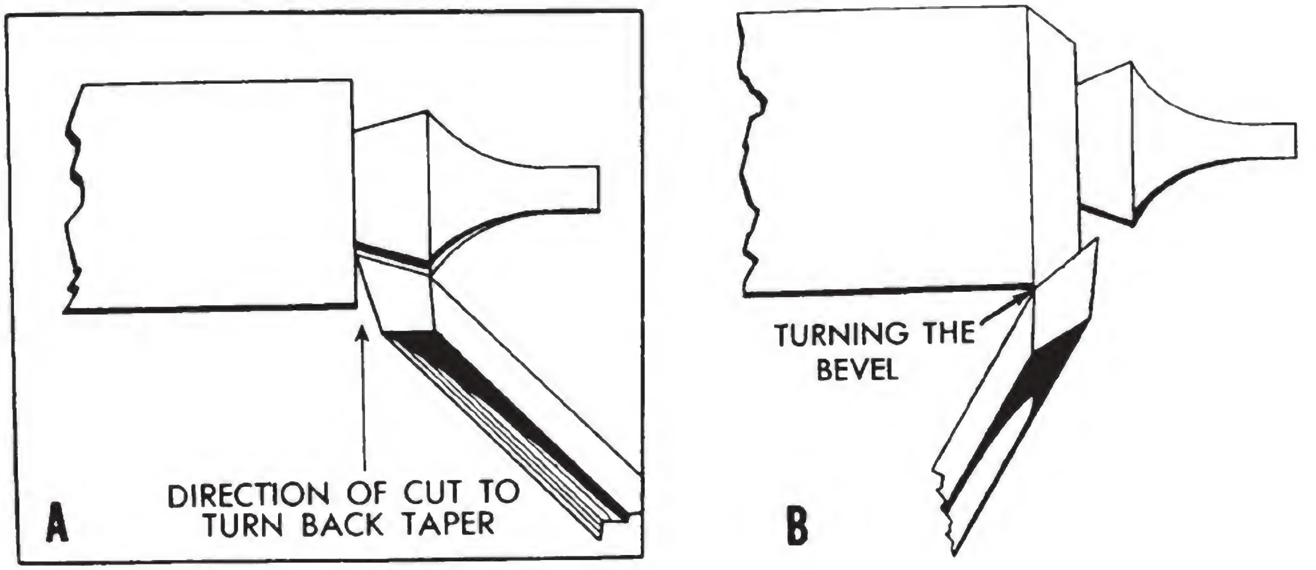

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Figure 11-15.—Putting a back taper on the cone, and turning a bevel on the collet shoulder.

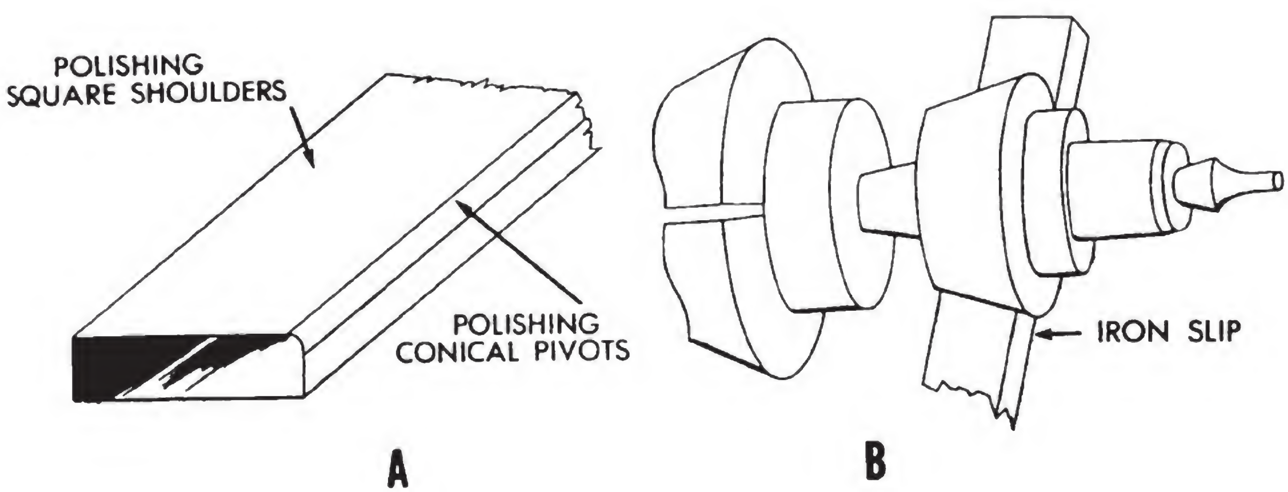

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Figure 11-16.—Grinding the hub and collet shoulder.

and the collet shoulder, in the manner illustrated in part B of figure 11-16. The purpose of this grinding is to remove turning marks and to get the correct diameter. Clean thoroughly with pithwood. CAUTION: You must have everything ABSOLUTELY CLEAN before you start to polish the staff.

To polish the collet shoulder and hub, put oil and a polishing powder (boron, diamantinne, etc.) on a bellmetal slip shaped like the iron slip and grind and polish to correct size. Use the rounded side of the oilstone and bellmetal slip. Frequently test the size of the pivot in the jewel hole to MAKE CERTAIN that you get the correct size.

At this point, reverse the position of the unfinished staff in the lathe and chuck it on the balance shoulder, as shown in figure 11-17.

Tighten the chuck enough to prevent the staff from falling out while you run the lathe and test the staff for trueness with your thumb. See figure 11-18. Apply a little pressure with the thumb.

Continue by tightening the chuck and examining the hub for trueness with a DOUBLE-POWERED loupe. Then rest a graver on a T-rest on the underside of the hub and check the space between the hub and graver while the lathe is rotating slowly for trueness of the staff (part A, fig. 11-19). If the space between the graver and the hub of the balance staff does not vary, you have the staff chucked true.

Using the sample balance staff as a gage, check the length of the hub of the new staff and

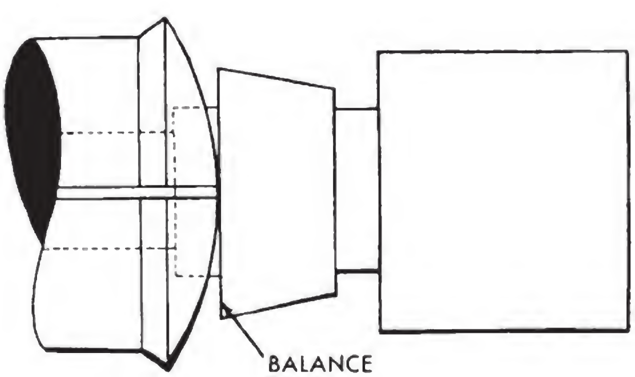

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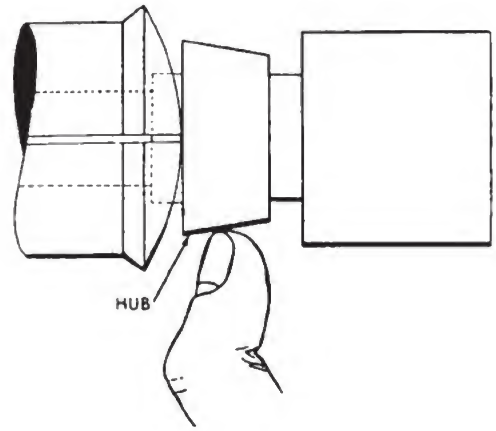
Figure 11-17.—Finished end of staff chucked on balance shoulder.



91.300X
Figure 11-18.—Truing an unfinished balance staff in a lathe.

make corrections, if necessary. Study part B of figure 11-19, with the sample staff in a pin vise.

Next, turn the roller shoulder with a sharp taper until you have its diameter .02 mm thicker than the roller shoulder of the sample staff (part A, fig. 11-20). Then undercut the roller seat very slightly, as shown in part B of figure 11-20. After you finish the grinding and polishing, the roller shoulder must still remain a square shoulder.

Now turn the lower cone and pivot, using the sample staff as a gage. See figure 11-21. Then select a sharp, pointed graver and turn a back taper on the cone (part A, fig. 11-22). Many staffs, however, are made without this back taper, as shown in part B of figure 11-22.

Your last step in turning a balance staff by Method No. 1 is to grind the lower part smooth with an iron slip charged with oilstone powder and then to polish it with polishing powder (diamantine). After you stake the balance wheel to the staff, burnish the ends and sides of the pivots.

Method No. 2

The second method for turning a watch balance staff is explained step by step in this section. Some watch repairmen prefer this method for turning the lower portion of a balance staff. One advantage this method does have is that it

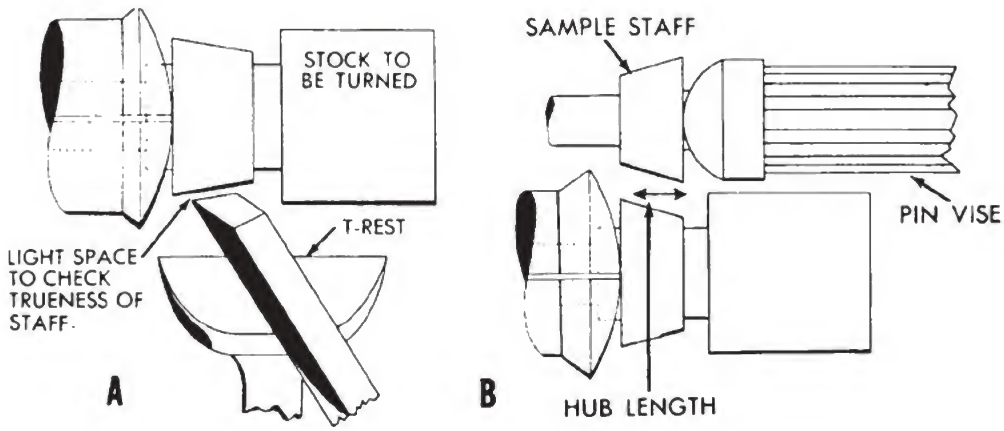


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Figure 11-19.—Testing the trueness of a chucked balance staff, and checking the length of the new hub.

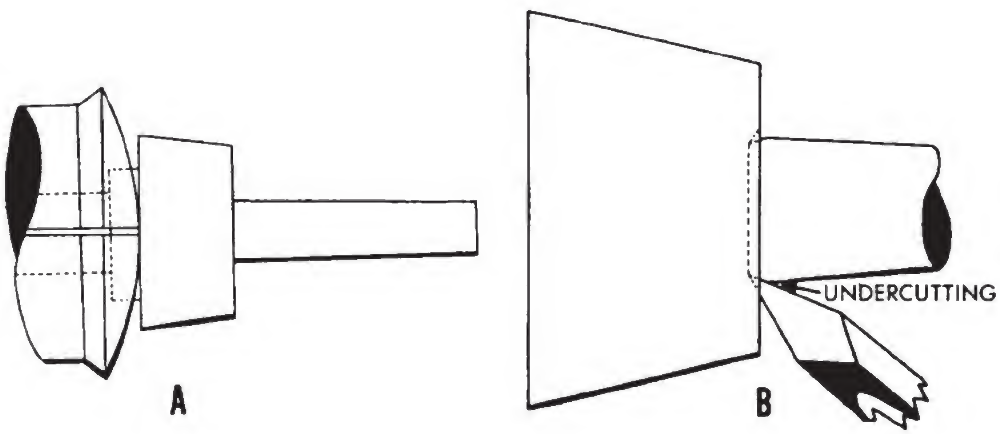

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Figure 11-20.—Turning the roller shoulder of a new balance staff.

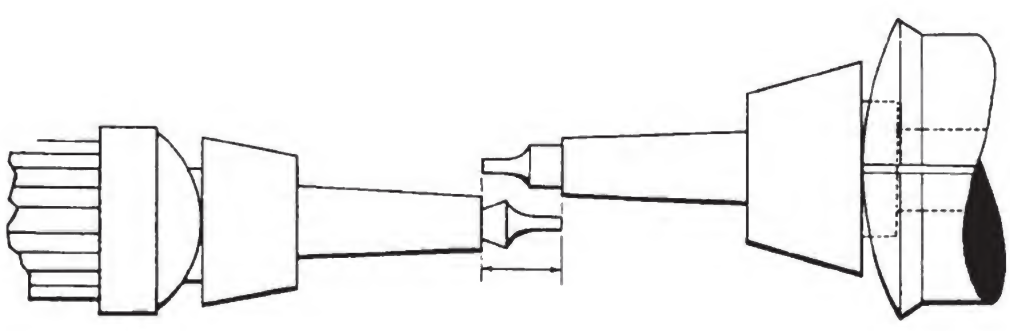

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Figure 11-21.—Turning the lower cone and pivot.

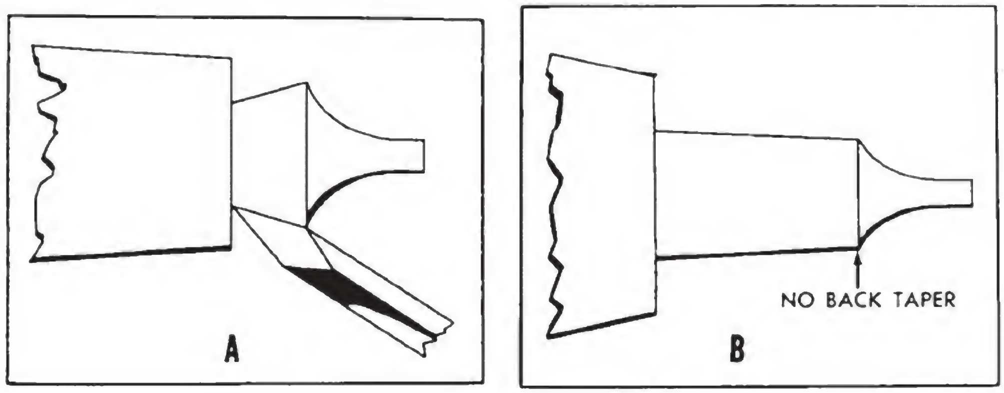

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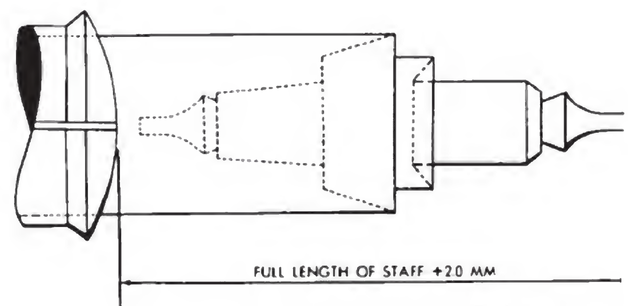
Figure 11-22.—Cutting a back taper on the lower cone; cone without back taper.



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91.305X

Figure 11-23.—Steel wire chucked in a lathe for turning the balance staff by another method.

ENSURES PERFECT CENTERING of the pivots of the new staff, as you will see by studying the procedure, as follows:

1. Chuck the steel wire selected for the balance staff in the lathe in the manner shown in figure 11-23. Note that the amount of the wire you should have extending out from the chuck is equal to the FULL LENGTH of the balance staff PLUS about 2 mm extra.

2. Follow the procedure explained in Method No. 1 for turning the top of the balance staff.

3. Rough out the lower part of the staff. CAUTION: It must be long enough to include the lower pivot. See figure 11-24.

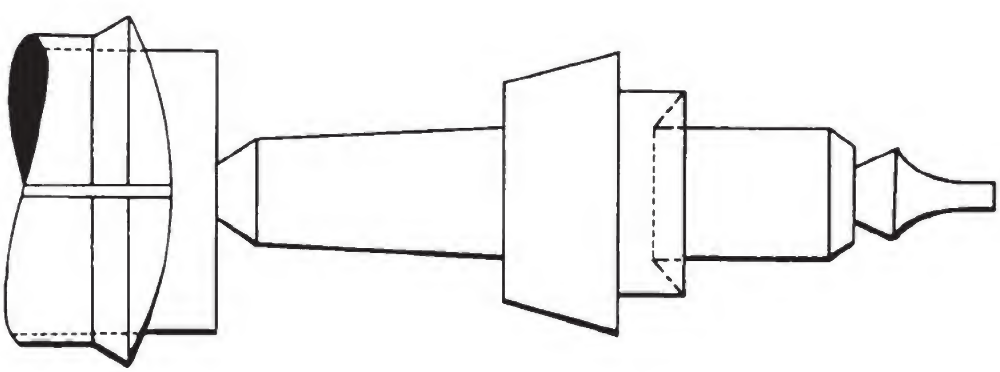

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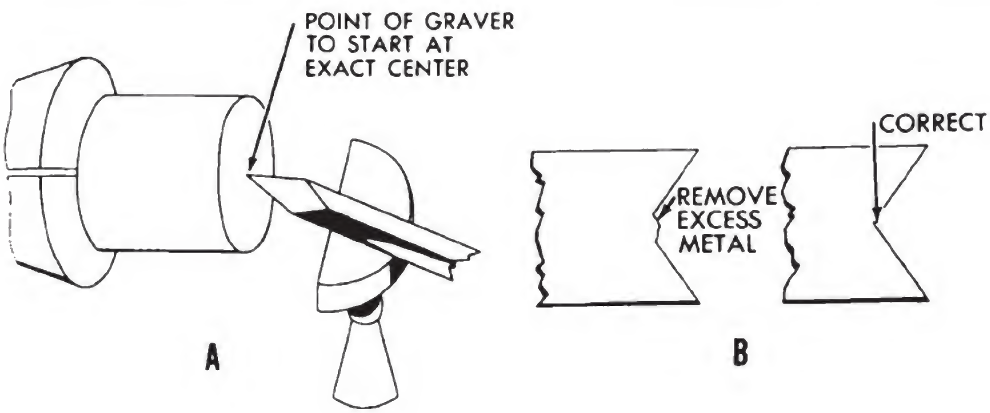
Figure 11-24.—Roughing out the lower part of a balance staff.



91.307X
Figure 11-25.—Turning the end of a new balance staff flat and cutting a reservoir in it.

4. Insert a brass chuck in the lathe and turn the end flat (part A, fig. 11-25). Then cut a reservoir in the piece of brass, starting at the point indicated in Part A of figure 11-25 and finishing as shown in part B of this illustration. Note the T-rest on which you should rest the graver while you make the reservoir. The reservoir must be deep enough to engulf the entire upper portion of the balance staff; and the V point must be the DEAD CENTER point in the brass. Study figure 11-26.

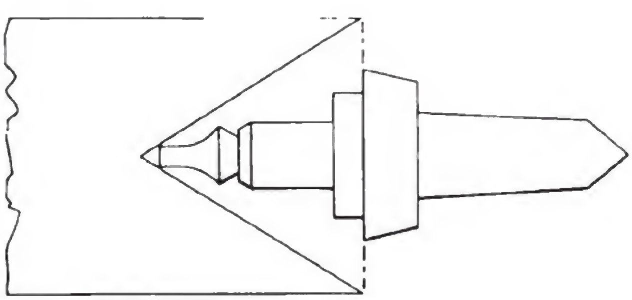


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Figure 11-26.—Correctly formed shellac reservoir.

5. Warm the end of the brass chuck with an alcohol lamp and pack your reservoir with shellac. Then apply more heat to soften the shellac.

6. Insert the finished portion of the balance staff in the soft shellac and apply enough pressure with a finger (with the lathe running) to push the pivot to the bottom of the V of the reservoir (fig. 11-27). Then keep the lathe rotating until the shellac hardens.

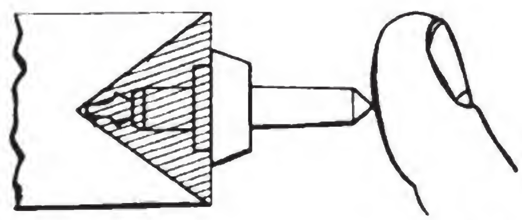

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Figure 11-27.—Inserting the finished portion of a new balance staff in soft shellac.

7. To true the staff, apply a little heat (enough to enable you to move the staff in the shellac). Then rest a piece of pegwood on the underside of the staff and true the staff with the lathe running. Barely touch the roller seat with the pegwood during the truing operation. Check the staff for trueness by the method previously described in this chapter. Study figure 11-28.

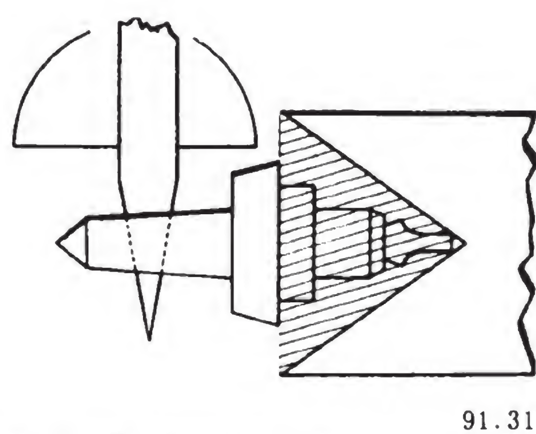

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Figure 11-28.—Checking a new balance staff in a shellac reservior for trueness.

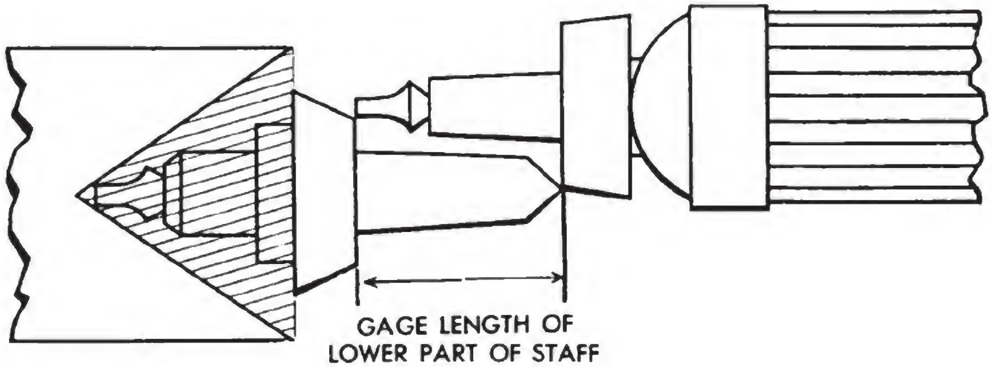

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Figure 11-29.—Reducing the lower part of a new balance staff to correct length.

8. Use the old staff as a gage and reduce the lower part of the balance staff to the correct length, as illustrated in figure 11-29. Then turn, grind, and polish the lower staff just as you did when you made a staff by Method No. 1 (in the discussion).

9. To remove the completed balance staff from the shellac, heat the brass until the shellac is soft and pull the staff out.

10. Boil the balance staff in water to remove the shellac residue which remains on it.

WATCH STEM

The tools you need for making a watch stem are illustrated in figure 11-30. If another watch stem is available, use it as a sample while manufacturing your new one. The procedure for making a stem follows.

Select a piece of soft steel wire whose diameter is slightly greater than the greatest diameter of the sample watch stem (or dimensions on your sketch). Then chuck the steel

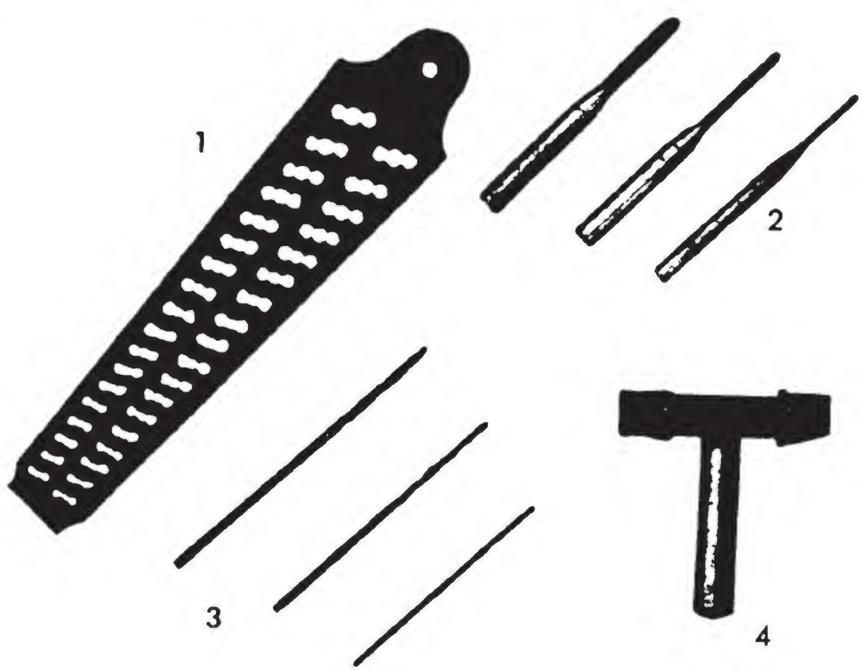

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Figure 11-30. —Tools required for making a watch stem.

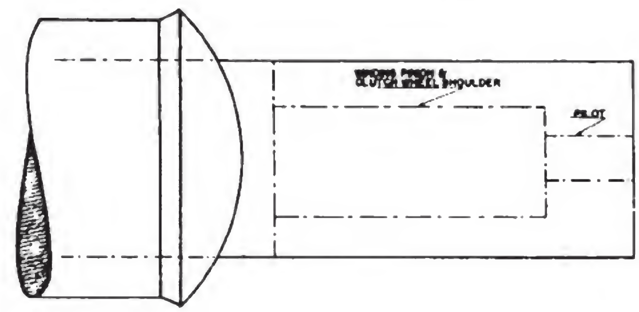

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Figure 11-31.—Steel blank chucked in a lathe for turning the pilot, winding pinion, and clutch wheel shoulders.

wire in a lathe, with enough of it protruding for the pilot, winding pinion, and clutch wheel shoulders. See figure 11-31. Next, place the sample stem parallel with the blank and make a mark on the steel wire with a graver to indicate the length to make the pilot seat of the new stem. Turn the pilot .02 mm larger in diameter than the sample pilot, and then corner undercut the square shoulder (fig. 11-32).

Turn the part of the blank protruding from the chuck .02 mm larger in diameter than the bearing of the sample, as shown in figure 11-33.

Continue the process by placing the sample stem parallel with the blank and marking the seat for the clutch wheel with a graver (fig. 11-34). If the sample is broken at the threads

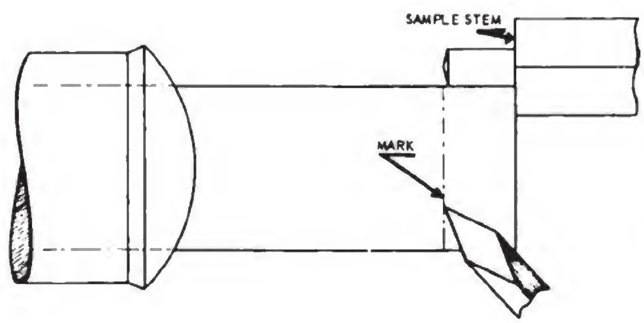

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Figure 11-32.—Marking the length of a pilot seat with a graver.

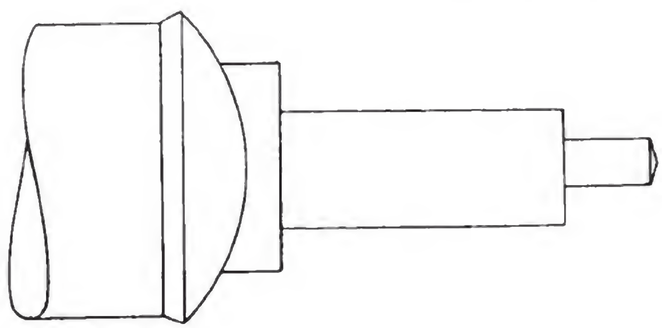

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Figure 11-33.—Turning the blank for a watch stem protruding from a chuck.

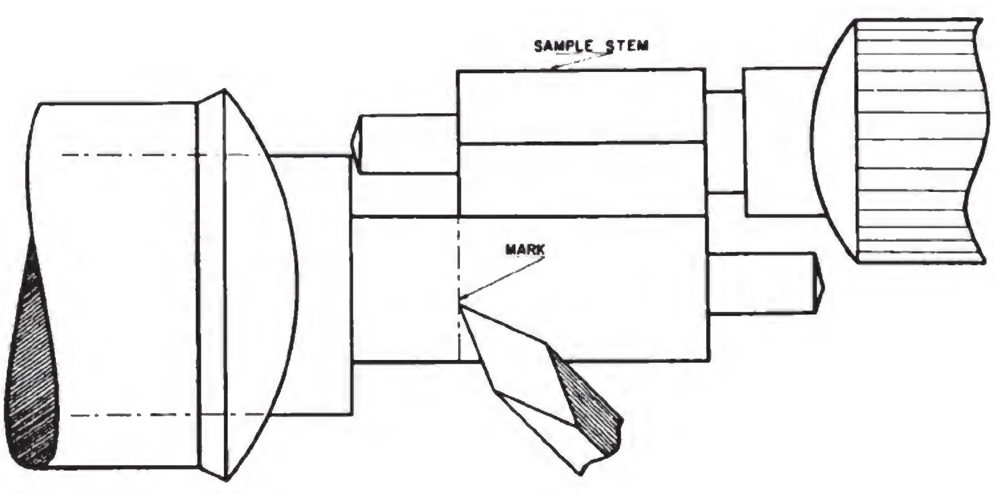

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Figure 11-34.—Marking the seat for the clutch wheel.

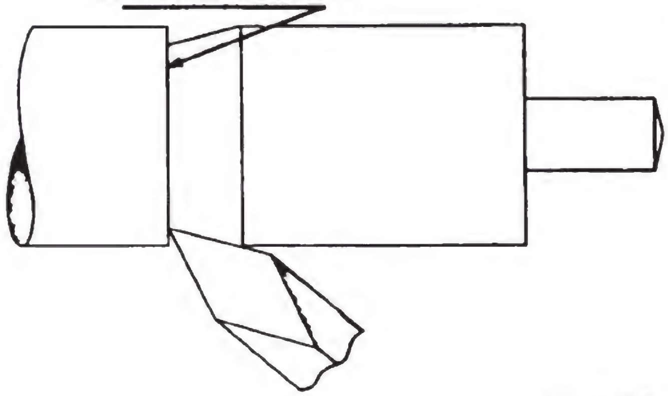

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Figure 11-35.—Turning a square shoulder for the seat of a clutch wheel.

or setting lever slot (usual breaking point), use the section with the clutch wheel shoulder to locate the seat for the clutch wheel. At this mark, turn a slight groove to make a square shoulder for the seat of the clutch wheel, as illustrated in figure 11-35.

Now remove the T-rest and replace it with the filing rest. Adjust this rest as necessary to get the top of the roller level with the blank and approximately 1/2 inch away from the work. Lock the head on the lathe with the index pin (fits in holes of index plate) and you are ready to file the square shoulder for the seat of the clutch wheel. Use a No. 3 file (with safe, non-cutting edge).

Place the file firmly on the roller and take three or four strokes with the safety edge OUT OF CONTACT with the square shoulder (fig. 11-36). Other strokes may then be made with the safety edge against this shoulder without fear of the file's going past it.

Take two more strokes with the file and then turn the headstock 1/2 turn (180°). Lock the headstock with the index pin and repeat the above filing procedure on this side of the blank. Use a micrometer at this point to check the diameter of the flat sides with the square of the sample. Then continue filing the same amount on each side until the diameter of the flat sides is equal to the square of the sample. Study figure 11-37.

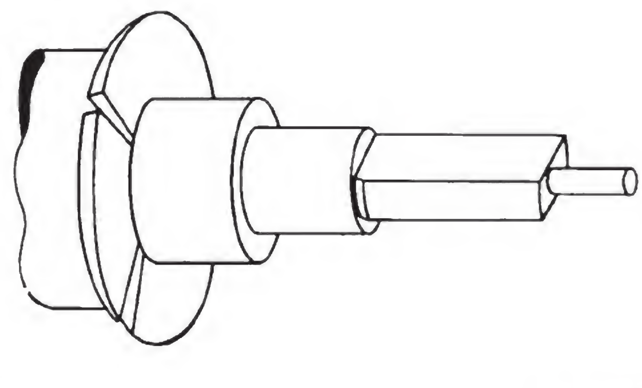

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Figure 11-37.—Second step in forming the square on the shoulder.

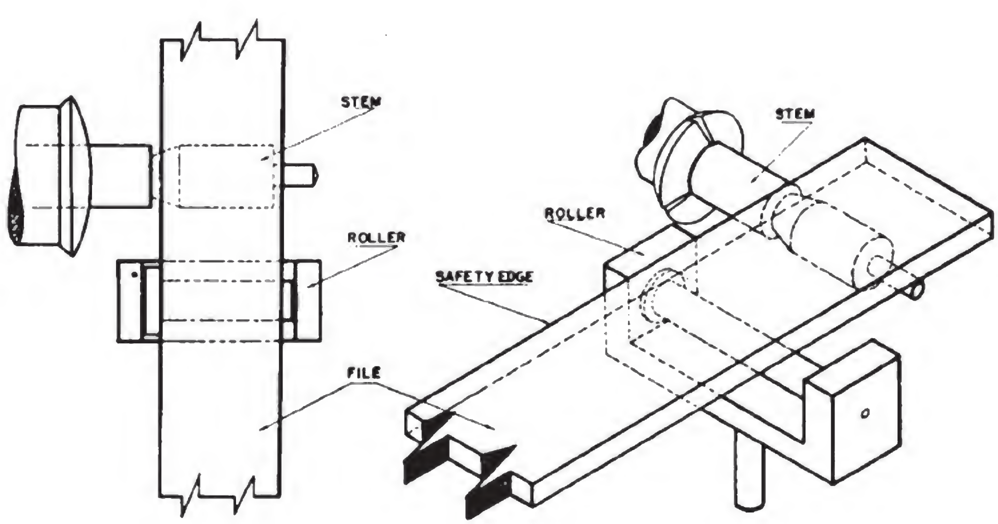

Figure 11-36.—First step in putting a square on the shoulder. 91.318X

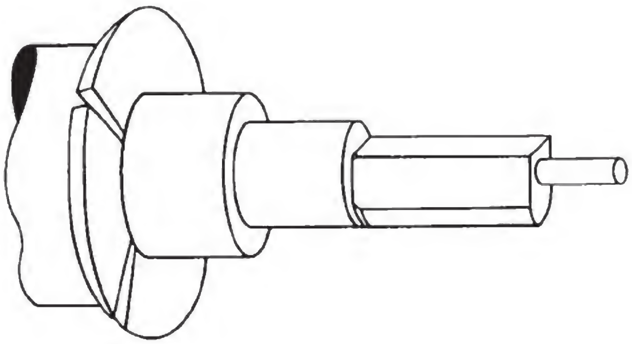

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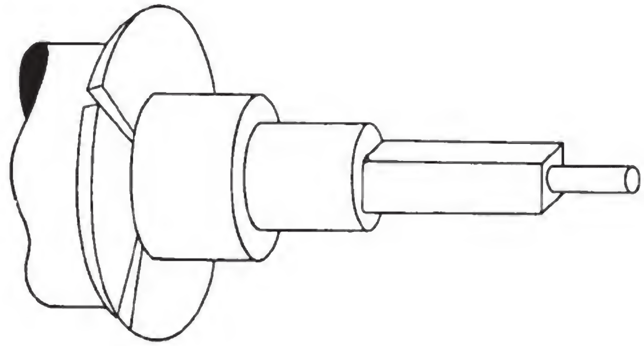
Figure 11-38.—Filing the third side of the shoulder.



91.321X
Figure 11-39.—The completed square.

Next, turn the headstock 1/4 turn (90°) and file the third side of the square, using the same procedure as for the first side, as indicated in figure 11-38.

Turn the headstock 1/2 turn (180 degrees) and file the fourth side. Use precaution in checking the diameter. When the square is completed it should look like the one on the stem shown in figure 11-39.

Put the unfinished stem parallel with the sample stem on the bench and mark the unfinished stem to indicate the threaded portion, as illustrated in figure 11-40, and then cut off the excess portion of the metal (left vertical mark in figure 11-40). In case the sample stem is broken at the setting lever slot, use the threaded section to mark the length of the threaded portion of your new stem. If the threaded portion of the sample is broken, be sure to make the threaded portion of your stem long enough to allow for the crown.

Use the right type of chuck to hold the bearing of the stem in the lathe and turn the shoulder for the threads. See figure 11-41. To determine the diameter of your new thread shoulder, make it small enough to fit in the screwplate hole which is two holes larger than the one you will use to cut the threads. CAUTION: In some screwplates, you must use just one hole larger than the one you will use for cutting the threads. Experience with your own screwplate will solve the problem of determining which hole to use for turning the thread shoulder. After you turn the shoulder for the threads, it looks like the one illustrated in figure 11-42.

To enable the screwplate to start cutting threads, turn a small taper on the end of the shoulder (fig. 11-42). Then continue with the cutting of the threads as shown in figure 11-43. Turn the screwplate with the right hand and the headstock of the lathe with the other hand. Use sufficient oil to make cutting easier

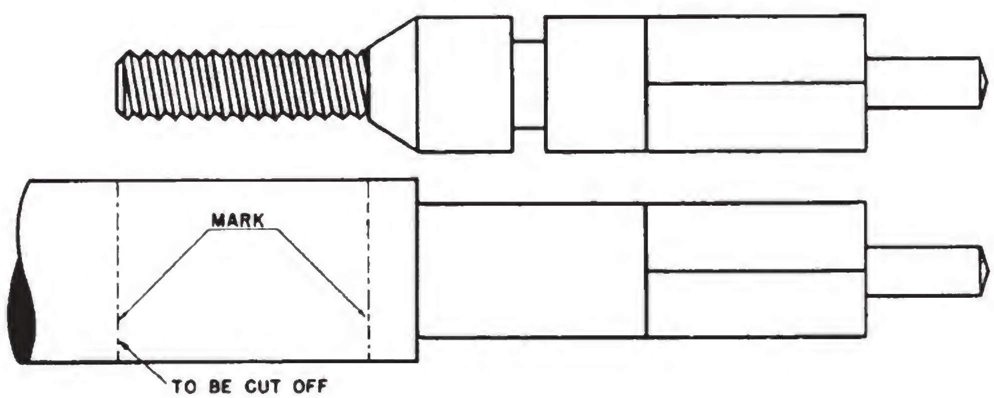


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Figure 11-40.—Marking the part of the new watch stem to be cut off.

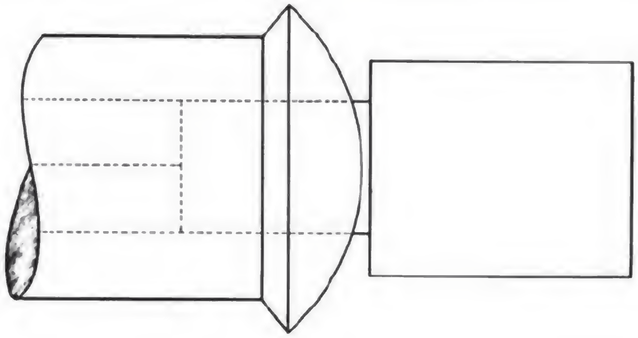

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Figure 11-41.—Turning the shoulder for the threads.

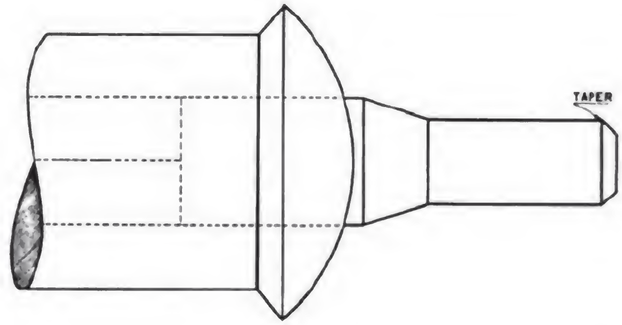

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Figure 11-42.—Stem shoulder ready for cutting threads.

and to prevent overheating of the metal. Move the headstock on one direction and the screw-plate in the other direction (backward and forward) until you get the threads cut the required length. Stop to add more oil, as necessary. CAUTION: If you try to cut the threads too rapidly, you may twist the shoulder off.

Before you turn the slot for the setting lever, harden and temper the unfinished stem.

Now chuck the stem in the lathe and place the sample stem parallel with the unfinished stem (part A, fig. 11-44). Then use a graver to mark the slot for the setting lever. (If the sample stem is broken at the setting lever slot, hold the sample stem parallel with the unfinished stem in the manner illustrated in part B of figure 11-44.)

With a special kind of graver (part A, fig. 11-45), turn the slot for the setting lever, same dimensions as the slot in the sample. Part B of figure 11-45 shows the completed setting lever slot.

To remove all traces of turning marks, grind the bearing and the pilot of the stem with a

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Figure 11-43.—Cutting threads on the shoulder.

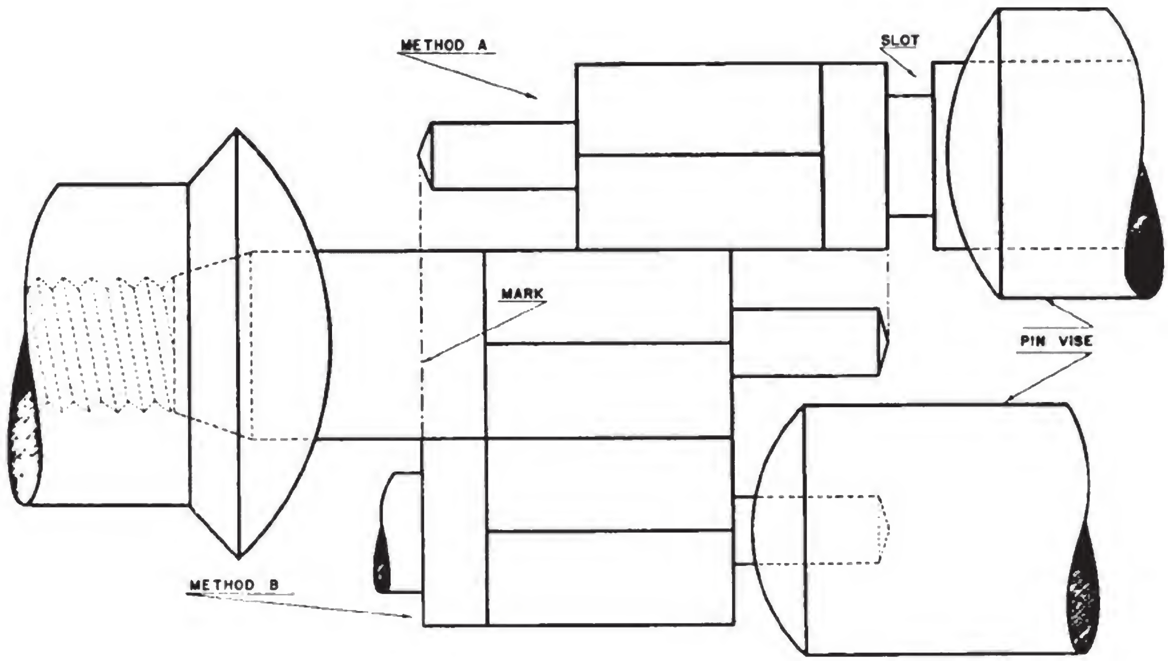

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Figure 11-44.—Marking the slot for the setting lever.

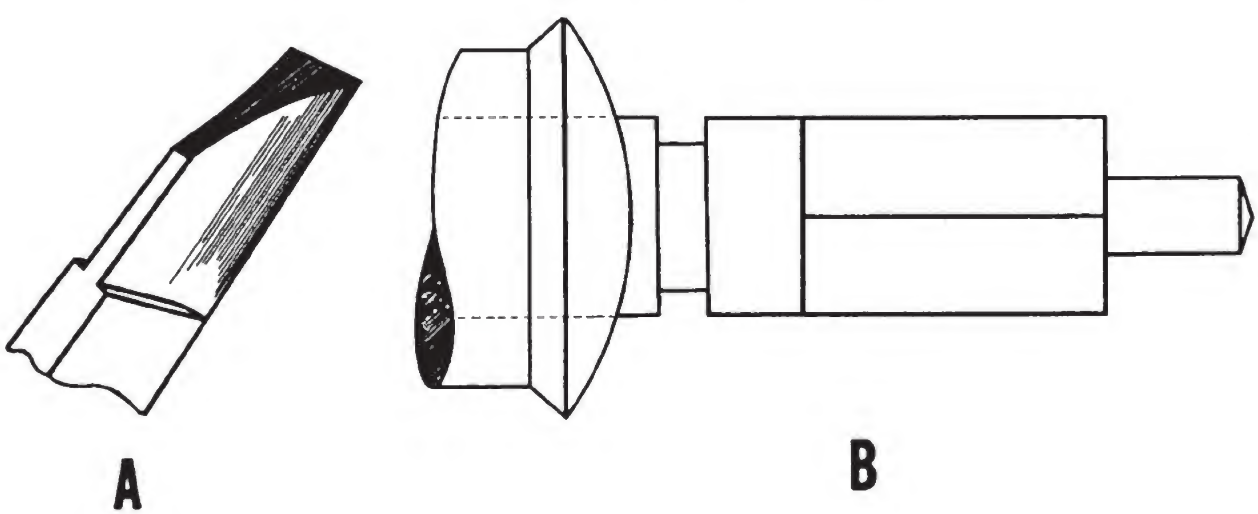

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Figure 11-45.—Turning the slot for the setting lever.

triangle slip charged with oilstone powder and oil. Then clean the stem thoroughly in preparation for polishing.

Chuck one female center in the headstock and another female center in the tailstock of the lathe. Fit the stem between these centers and check it for freedom of movement. It must move freely in order to find its own level when you apply a little pressure to the polishing slips. Using the same procedure you followed for grinding and polishing the bearing and pilot, grind and polish the square of the stem. This is the last step in making a watch stem to match a sample stem. Your new item should look like the one shown in figure 11-46.

MAINSPRING BARREL ARBOR

Although this section deals primarily with the procedures for making a mainspring barrel arbor, you will learn by studying it how to make most any type of arbor for pressure gages, watches, and clocks. As explained previously, whenever possible, use another arbor as a sample when you make a new one. Even though worn or broken, you can still use it as a guide in obtaining the correct contour for your new part.

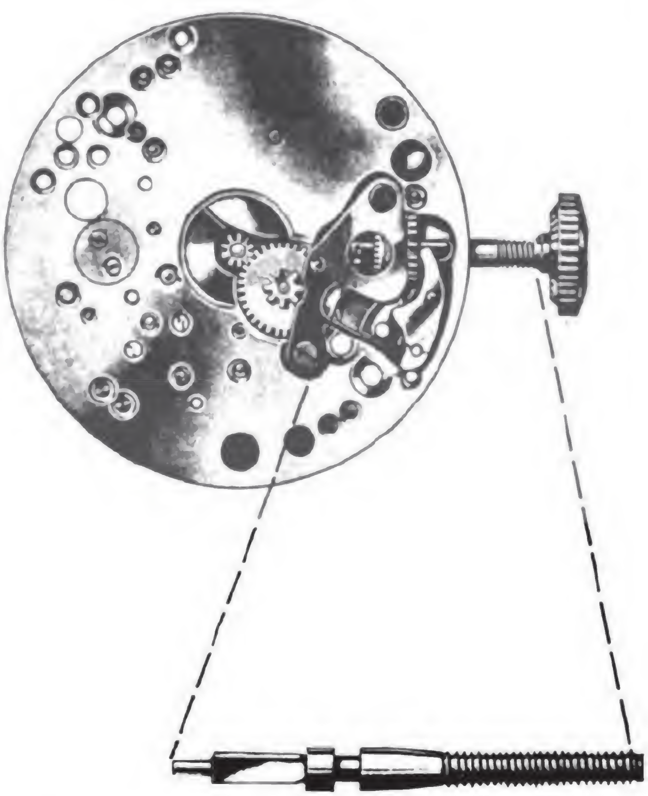

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Figure 11-46.—The completed watch stem.

Select for your new barrel arbor a steel rod slightly larger in diameter and longer than the sample arbor, or in accordance with a sketch for the new arbor. NOTE: It is ALWAYS BEST to prepare a sketch for most new parts you must manufacture; and information on the sketch (dimensions and specifications) is invaluable for making some instrument parts.

Unless it is too small to hold the rod in the lathe, use an ordinary split chuck; if necessary, use a larger screw chuck. You can adjust the screws of this chuck one at a time to center the rod. Then use a graver (with T-rest) to cut the rod to correct length and to turn one end of the arbor almost to the finished size. Then reverse the rod in the lathe, centered in a split chuck, and turn the other end almost to size.

Make the upper pivot of the new arbor square. Tighten the part in the lathe and lock the headstock with the index pin in one of the quarter holes on its pulley. Then position the roller rest in the T-rest in the way necessary to get the top of the roller a little above the center of the arbor. Hold the roller rest firmly and use a fine, flat file in the horizontal position while you file one side. Turn the headstock 180° and lock it, and file 10 to 12 strokes on the side opposite the first one you filed. Turn the headstock 90° and file the third side; and then turn it 180° and file the fourth side. Check the dimensions frequently as you file to make certain you are fashioning the pivot correctly and making it square.

Now check the ratchet wheel on the arbor. If necessary, reduce the size of the square in order to get a good fit. If the ratchet wheel is the type which is held in position by a screw, turn away all the square section of the arbor not required for the ratchet wheel and tap the remaining part for the screw.

Next, make the hook on the arbor body which holds the mainspring. Tighten the arbor in the split chuck and lock the head again with the index pin. With a fine jeweler's file, cut a slot across the arbor body. Then remove the arbor from the chuck and cut two broad slots perpendicular to the first slot (part B, fig. 11-47). Continue filing with the flat side and the edge of a file

until you fashion the hook in the manner shown in parts B and C of figure 11-47. The depth of the slot between the hook and the body of the arbor should be the same as that of your sample hook, and the face (where the spring hooks) of the catch should be square with the bottom of the slot, or cut to a slight angle toward the out side of the arbor (to hold the spring better). The depth of the slot (height of the face of the hook) should be equal to the thickness of the mainspring.

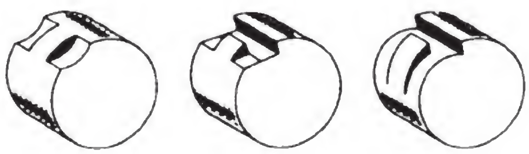
A B C

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Figure 11-47.—Forming the hook on a new mainspring arbor.

To harden your new arbor, heat it to a cherry red color and then plunge it into cool oil; to temper the arbor, heat it to a pale straw color and cool it in the atmosphere.

Polish your new arbor all over with a bell-metal slip charged with oilstone powder and oil. Polish both pivots with an iron slip and diamantine.

When you finish polishing the new arbor, mount it in a split chuck and turn the arbor body enough with a sharp graver to get the measurement of the shoulder which turns inside the barrel slightly less than the full diameter of the body. Give the new part a slight teper, to allow the pivots to receive oil. Reverse the arbor in the chuck and finish the other end in the same way.

INSTRUMENT BUSHINGS

Because Navy watches have jeweled bearing surfaces for most of their wheel arbors and balance staff pivots, you will seldom (if ever) be required to insert bushings in watch plates; but you will have to put new bushings in clocks and gages.

If you find a non-jeweled clock plate bearing scored or oval-shaped, plug it and also the two adjacent bearings. With dividers centered on the adjacent bearings, inscribe arcs on the plate. Record the radius of each arc, so that you can check the new bearing center later. Use a cutting broach to shape and smoothen the damaged bushing hole. Be careful about retaining the original center. This procedure is followed for both clock and gage plates.

Drilled brass bushing rods can be procured in assorted lengths from 2 1/2 inches up, and from 1/16 to 1/8 inch in diameter. The hole in the rod you select for replacing a bushing should be slightly smaller in diameter than the pivot which is to fit in it. The length of the rod selected for the bushing should be four times as long as the finished plate hole.

After you select a bushing rod of the correct size and length for a plate hole, proceed as follows to make the bushing:

1. Turn the bushing rod on an arbor until it has the same taper as that of the broach.
2. Enlarge and smoothen the plate hole until it has exactly the same taper as the bushing rod.
3. Pass the rod through the smoothened plate hole and mark it at two points: (1) a small distance above the plate hole, and (2) a small distance below the plate hole.
4. Turn off the extra amount of rod at each end.
5. Undercut the top end of the rod to enable you more easily to form a rivet, and chamfer the upper side of the hole to receive it.
6. Next, put the plate and rod on a staking tool (underside of plate up) and fasten the rod tightly in the plate with a flat-end seating punch. Repeat this operation on the other side of the plate, but use a round-end spreading punch. Use light taps with a hammer to rivet the chamfered side.
7. If the new bushing is too long, cut enough off the tapered end to make the length correct. Then polish the edges of the bushing with an India stone slip.
8. Verify the center of the new bushing by checking it with the intersection of the two arcs you previously described. NOTE: The center of the new bearing must coincide with the original center of the hole.
9. Open the new bushing to the correct size with a tapered broach, and finish it off with a round broach to polish the hole.

JEWEL MOUNTINGS

Watch jewels are inserted directly into the plates in many watches; but in a large number of other watches the jewels are first mounted in brass or gold settings, and then

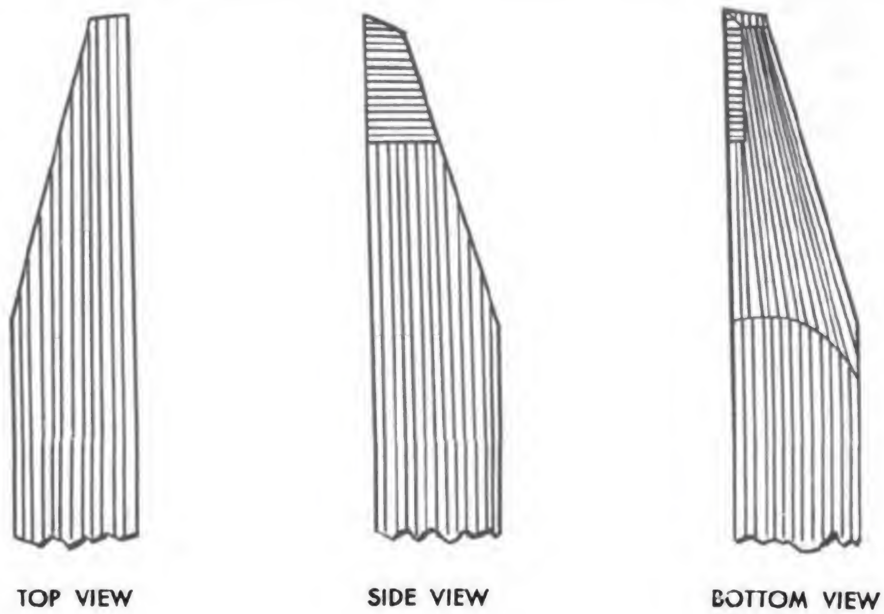

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Figure 11-48.—Special jewel graver with inlaid cutting edge.

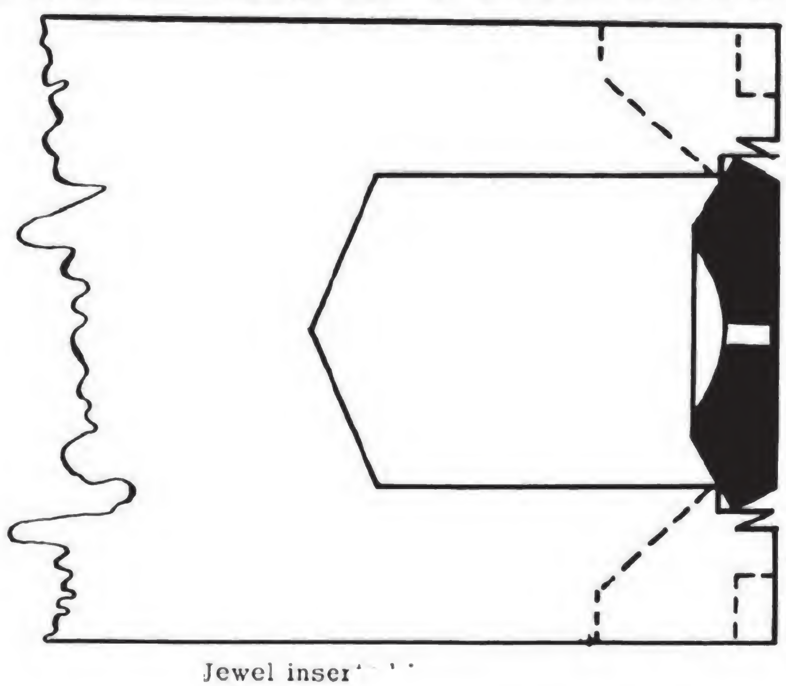
both settings and jewels are fitted friction-tight in the plate. A jewel mounted in this manner is called a BEZEL jewel. On occasions, however, you will need a jewel mounting which cannot be replaced from stock and your only alternative is reproduction.

The procedure for making a jewel mounting is described in the next paragraphs, as follows:

1. Chuck a piece of 4 mm brass wire in a lathe and square off the face with a graver. Then turn a small center in the new face.

2. With a drill slightly smaller in diameter than the jewel which will fit in the mounting, drill a hole approximately 5 mm deep in the brass wire. Select a jewel graver with an extremely hard, inlaid cutting edge (fig. 11-48) and enlarge the hole slightly. Then true the hole.

3. Next, turn the jewel seat (fig. 11-49) to a depth a fraction more than the width of



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Jewel inser

the jewel for which it is intended. When you insert the jewel, it should lie a little below the face of the mounting.

4. Now select a long, pointed graver and cut a groove close to the opening of the surface of the mounting.

5. Then check the dotted lines in figure 11-49 to learn how to turn the setting so that it fits the watch plate.

6. Continue the process by moistening the jewel with oil (to hold it in place) and by inserting it in the mounting. In order to set the jewel securely, rest a jewel burnisher on the T-rest and spin the metal adjoining the groove onto the jewel.

7. Before you cut off the unused part of the brass wire, check for endshake. If the amount of endshake is satisfactory, cut the wire off, turn it to the proper thickness, and strip it out with a sapphire jewel stripper or a highly polished graver. Polish the face by sliding it over an agate polishing stone or a similar finishing agent. The mounted jewel is then ready for insertion in the plate. When you do this, adjust for endshake by raising or lowering the jewel in the pillar plate.

When you replace a balance hole jewel in its old setting, allow a clearance of .01 mm to .02 mm from the bottom of the hole to the outer edge of the setting—to ensure proper capillary action of the oil when the endstone is in position against the pivot. If your mounting appears to fit loose, spread it by tapping it on a staking stump with an inside taper punch.

OTHER INSTRUMENT PARTS

The term OTHER INSTRUMENT PARTS has reference to instrument parts mentioned in the beginning of this chapter which you may be compelled to manufacture but which have not been discussed in this chapter. The manufacture of all these parts has not been considered for two reasons: (1) space in this chapter does not permit a detailed discussion of the manufacture of all of them; and (2) if you understand the procedure for making the typical parts which have been discussed, you will be able to make other similar parts.

CHAPTER 12

FLOWMETERS—LEVELOMETERS—LIQUIDOMETERS

Before you can qualify for advancement in rating to an Instrumentman 1, you must understand the "procedures for repairing and calibrating" such measuring instruments as levelometers, liquidometers, and pyrometers. In order for you to qualify for advancement to a Chief Instrumentman, you must know how to make a casualty analysis, and how to overhaul and calibrate liquid flowmeters.

Before you study the discussion of measuring instruments in this text, review the chapter in Instrumentman 3 & 2, NavPers 10193-B, on tank level indicators and liquid flowmeters. That chapter tells how these gages and meters operate and briefly explains some maintenance procedures; whereas, this chapter emphasizes servicing and overhauling. Because of the limitation on space, however, all the details of servicing cannot be considered; but they are discussed fully (including overhaul) in NAVSHIPS 387-0276. Keep this manual available for ready reference when you are working on liquidometers and levelometers.

FLOWMETERS

A flowmeter is an instrument which measures the rate of flow of a liquid, gas, or steam through a pipe line. Several different types are discussed briefly in this section, with some emphasis placed on maintenance.

TYPES OF FLOWMETERS

Two types of flowmeters, Niagara and American, manufactured by the Buffalo Meter Company, are used rather extensively by the Navy. The American name is applied to COLD WATER meters with bronze casings. The standard body model is known as the SOLID CASING type, but some cold water meters (small types) are also made with FROST BOTTOMS, which prevent damage to the mechanisms of meters if freezing occurs. The connections are placed in the top casings and the bottom casings are made slightly weaker, so that excess pressure exerted by the ice will break out the CENTER section.

All meters must be used ONLY for the purpose for which they were ordered—measuring the flow of cold water, hot water, petroleum products, chemical solutions. Materials used in the meters, and calibration, are substantially different for each class. Cold water meters, for example, are damaged by heat or oil; oil meters are damaged in one day by water. Chemical meters are specially constructed for the particular chemicals specified by the Navy when the meters are ordered. The meters are built and hydrostatically tested for 150 psi of pressure, but many sizes can be used at higher pressures when they are not subjected to liquid hammering or shock. Always avoid the combination of LIMIT of pressure and HIGH temperature.

Buffalo meters use nutating pistons to measure the rate of flow of liquids in a pipe line. When the liquid enters the chamber of the meter, it lubricates the internal gears and moves downward through the measuring chamber into the base of the meter and discharges through the meter outlet. The liquid in the measuring chamber drives a single measuring piston which nutates (rocks) around on its central ball. (Review the illustration of a Niagara meter in the chapter on flowmeters and tank level indicators in Instrumentman 3 & 2, NavPers 10193-B.) A positive displacement roller (cam) controls the movement of the piston and compels it to make a complete nutation at each movement. The position of the piston divides the chamber into compartments which are successively filled and emptied. Each compartment holds a definite volume.

The movements of the piston are transmitted by a train of gears to the meter register. Bearings of the submerged gears carry the weight of the gears on the tops of the gear posts, and they form an enclosed, dirt-proof construction. For cold water meters only (in most sizes), the gears may be placed in a grease-filled chamber. Oil meters are all metal. Gasoline meters and oil meters have pistons with semi-steel bearings in bronze seats. Casing for these meters are usually cast semi-steel, hot-zinc dipped, or bronze.

The amount of displacement by a single movement of a piston remains constant for a specified liquid. When the gear train is correct for a specific meter, accurate registration on the meter is assured. Each meter is individually tested and calibrated at the factory to run within close tolerances at all rates of flow for its rated capacity, on the liquid for which it is made to measure.

The Bristol Manufacturing Company also makes flowmeters with different types of measuring elements. One type uses a U-tube mercury manometer for measuring the rate of flow where the differential pressure is between 10 inches and 300 inches of water. The manometer is made of forged steel. Connections between the chambers are screwed and welded, and parts within the mercury chambers are made of stainless steel. The stuffing box is pressure-tight and requires no lubrication. This feature eliminates leaks and shaft freezing.

Another type of bristol flowmeter employs a single or a multiple capsule as the measuring element. Motion of this element, caused by pressure changes, is transmitted by a pressure-sealed lever arm. This meter measures the rate of flow of gases.

Bell-type manometers are used in Bristol flowmeters for measuring low differential pressure where the static pressures exceed the 25 psi limit for the capsular type, low-range, differential pressure measuring unit.

Dri-flo bellows manometers are employed by Bristol as measuring units for measuring differential pressure from 0 to 20 inches and from 0 to 400 inches, for liquid flow. The bellows is made of stainless steel (one piece) and is leak-proof. Motion of the bellows is through a torque tube. A built-in compensator corrects for changes in ambient temperature, ensuring accurate operations from -30° to +170°F.

Bristol also manufactures an electric flowmeter for remote measurement of the rate of flow of an element. This meter consists of a transmitter and a receiver. The transmitter measures by means of a transmitter body the differential pressure across an orifice plate, venturi tube, or flow nozzle in the line through which the liquid passes. The differential pressure reading is indicated on a scale in the transmitter and then transmitted to the receiver, where it is recorded on a chart or indicated on a scale in terms of rate of flow.

MAINTENANCE

Some of the tools and equipment you need for servicing a flowmeter are: screwdrivers, assorted sizes; adjustable wrenches, hammer; wire brush; extra-fine emery cloth; scraping tools; stuffing box wrench (provided by the company); acid bath for cleaning bronze parts; motor-driven rotary wire brush for cleaning rough surfaces; and testing equipment (for testing accuracy of measurement).

The general repair procedure for flowmeters follows.

Casualty Analysis

The first thing to do with an inoperative or defective flowmeter is to make a casualty analysis to identify operating difficulties. Enter your findings on a casualty analysis report. Some of the things to inspect on a Niagara meter are:

1. Non-registering. This difficulty is generally caused by swelling of the hard rubber disk piston as a result of heat; but the trouble may be in the register.
2. Inaccurate running. This trouble is usually the result of an error in calibration, slight wear, or a change in viscosity of the liquid being measured.
3. Over registering. Erratic registering (over) generally indicates that air, steam, or other gases are passing through the meter along with the liquid.
4. Under registering. Under registering may be caused by severe wear of parts or partial clogging of the meter.
5. Erratic hand action. If the dial hand stops and then jumps ahead, there is usually difficulty with the meshing of the change gears.

6. Leakage of metered liquid. Leakage of liquid at the point where the register is attached to the meter body indicates that the stuffing box packing is loose or that the temperature is TOO HIGH for the packing used. Meters used for temperatures under 150° F have composition cork packing; graphite asbestos packing is used for temperatures above 150° F.

When you make a casualty analysis, ALWAYS disassemble the meter to the extent necessary in order to locate trouble. If you intend to overhaul the meter, however, completely disassemble it and inspect all parts for swelling, wear, or any type of damage.

It is best to inspect each part as you remove it from the meter. Dispose of parts which are not usable. ALWAYS keep the parts of a meter together; they CANNOT be changed with parts of another meter. To avoid mixup of serial numbers, keep the register box with the meter body.

Cleaning Procedure

Be sure to follow the manufacturer's instructions when you clean parts of a flowmeter. Give each part a second inspection, and protect reusable parts from loss or damage.

Clean foreign matter from the piston with a wire brush or very fine emery paper. CAUTION: Do NOT reduce the diameter of the central ball, or round its edges. If the ball is made of metal, scrape off foreign matter.

Clean horizontal-type registers (not rubber-bushed, round-reading types) of grease and dirt by boiling them in a caustic or degreasing solution. Dip a round-reading register in an acid bath to clean it; but then take the register apart and clean traces of acid from bearings. Clean vertical registers in gasoline or a similar approved solvent. After you clean and wash a register, oil it with an approved clock oil.

CAUTION: Clean all parts in accordance with instructions; then wash and dry them.

Repairs

The first rule to follow when you repair flowmeters is this: Replace all parts which may adversely affect its operation. If there is doubt in your mind relative to wear or warping of a part, replace it. Some of the things you should inspect when you are repairing a meter include:

1. Disk pistons. Test the flatness of a metal disk with a straight edge. If it is warped, replace the entire piston (disk only in a three-piece construction).

2. Piston ball and measuring chamber. Replace a disk or vertical wall of the measuring chamber when rubbing or scuff marks are noticed. Remove the marks, if possible, provided no damage exists. Grasp the disk pin in one hand and move the piston up and down to ascertain the amount of clearance, which should be NO MORE THAN .01 inch (vertical) in meters for low-temperature service and .020 inch for meters intended for high-temperature service.

3. Diaphragm. If the diaphragm is so worn that the surface is rough, replace it. Turn the disk. If it catches or sticks momentarily on the diaphragm at some point, the diaphragm needs attention.

4. Intermediate gear plate. The shaft with its driver block and pinion must revolve freely, but without much wear in the shaft or bushing. If the roller is worn, other parts of the gear plate are most likely worn and require complete replacement.

5. Repacking stuffing box. Remove the old packing and check the shaft to determine whether it has score marks. If it is scored, replace it. If the hole passing through the top casing on a small meter is worn, replace the top casing. Put new bronze stuffing box plugs in large meters. Follow instructions in the technical manual when you replace graphite-asbestos packing in chemical-measuring meters.

When you complete the repair of a flowmeter, test it for accuracy. You can do this by the change gears or by the accuracy adjusting screw (on some models, particularly those used for measuring low-viscosity oils). ALWAYS test for accuracy against a standard, such as a calibrated volume tank, and run tests at the normal rate of flow at which the meter will be used. Also, when you make the test, have the control valve as close as possible to the end of the line and on the outlet side of the meter.

To make an accuracy test of a flowmeter, run liquid through the meter and piping until all air is flushed out; then continue to run the meter until the test dial hand is at zero. (Set a vertical dial hand at zero.) Continue by running through the meter the desired quantity of liquid, stopping the test in accordance with the reading of the meter. Then measure the amount delivered and compare this amount with the

indicated amount on the meter dial to determine the percentage of error, if any. Make three tests to be sure that the meter runs uniformly. If variations on your tests are small, average the three tests; if you find large variations, locate the difficulty and correct it. Then test again.

For additional information on flowmeters, study the manufacturers' technical manuals for specific types. You need these manuals when you repair, test, and calibrate flowmeters.

LEVELOMETERS

Levelometers are tank level indicators which employ the hydrostatic principle of operation. Instrumentman 3 & 2, NavPers 10193-B, contains one chapter on levelometers, liquidometers, and flowmeters. Review that chapter, and then study the following discussion on maintenance and repair of levelometers and liquidometers.

When you start to repair a levelometer, do the following:

1. Make a preliminary check of the indicator. Take several readings by operating the hand pump, or by opening and closing the air supply valve on a constant-air model.

If the pointer is erratic, contents from the tank are in the bellows, liquid or condensate is in the line, or the indicator is defective. Correct the first condition by disconnecting the lines and looking for signs of tank contents, or corrosion around the bellows and mechanism. If either of the last two conditions exists, tag the old indicator for overhaul and install a new one. Remove liquid or condensate from the line by blowing it out. Then connect the lines and make another check. If the indicator is defective, tag it for overhaul and install a new one.

If the pointer of the indicator DROPS when no liquid comes from the tank, there is a leak in the indicator mechanism or in the lines. Apply pressure to the indicator and observe the reading. If it decreases while the pressure is retained, the indicator is defective; if the pointer holds its position, the leak is in the system and not in the indicator.

When the pointer remains on or beyond the FULL mark, even though the tank is NOT full, there is a pinched measuring line or a clogged air bell, or there may be a clogged orifice or clogged pressure snubber in the indicator. Rectify the first condition by blowing the line and air bell out. If the bell is clogged, repair it. You can also repair a clogged orifice or pressure snubber; but if this action does not remedy the difficulty, overhaul the indicator.

2. Remove and repair the indicator. On constant-air models, shut off the air supply first and then disconnect the measuring line at the indicator. If the indicator is on a pressure tank, vent the tank first and then shut off the compressed air before you disconnect the line.

MODEL 80 TEST INDICATOR

You need a Model 80 test indicator, or a water column, to apply pressure corresponding to FULL or HALF-SCALE pressure when you service a levelometer. Study figure 12-1, which shows a Model 80 test indicator installed on a test panel. For tanks ranging in height from 36 inches to 11 feet of water, or equivalent, use a Model 80-4 test indicator, and use a Model 80-3 on tanks ranging from 11 feet to 100 feet of fresh water, or equivalent.

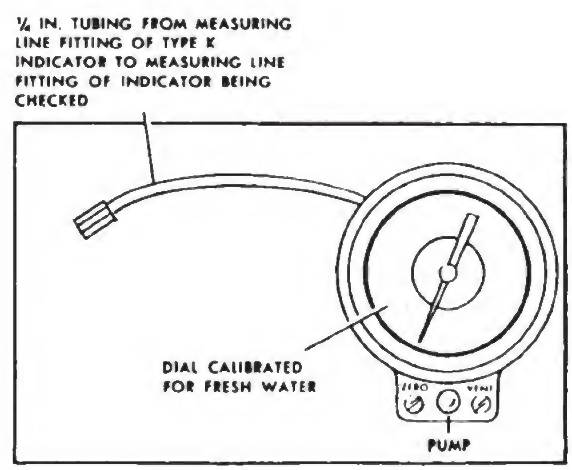

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Figure 12-1.—Model 80 test indicator installed on a test panel.

The test indicator dial is calibrated in inches, to correspond to a head of fresh water. Additional scales can be provided for fuel oil, gasoline, or other liquids; but if you have dial markings for fresh water ONLY, calculate the full-scale setting for other liquids in the following manner:

1. Subtract the bell loss (normally 2 inches) from the tank height.

2. Multiply your result by the specific gravity of the liquid stored by the tank and add 2 inches to your product.

The procedure for adjusting an indicator with a Model 80 test indicator follows.

1. Connect the tubing from the test indicator to the measuring line fitting of the indicator you are adjusting.

2. Using the zero adjustment on the test indicator, position the pointer of the indicator at EMPTY (no pressure in system).

3. Operate the hand pump on the test indicator until its pointer, is at the FULL or HALF-SCALE fresh-water height for the indicator.

4. Release the pressure by using the vent on the indicator, if there is one; otherwise, use the vent on the test indicator.

Before you connect an indicator to a Model 80 test indicator, or a water column, pressure test it. Connect a small hand pump to the measuring line fitting, put an appropriate valve between the pump and the indicator to prevent leakage, and pump the indicator approximately to the FULL mark. Let it stand 5 minutes and then adjust the indicator, if the pointer does not drop and the indicator action does not seem sluggish.

ADJUSTMENTS (MODEL 10 INDICATOR)

Adjustment of a Model 10 hydrostatic gage, illustrated in figure 12-2, is different from the adjustment of other models. The procedure follows:

1. Inspect the pointer for clearance of the dial and the lens. If it is bent, straighten or replace it; if the shaft is bent, install a new movement.

2. Check the link (illustrated) at both ends for binds, and for freedom with the pointer. Inspect also the hairspring and the end play in the pinion and sector gear shafts. If the shafts bind, install a new movement and POSITION the linkage. If there are visible defects or damage, overhaul the indicator.

3. Remove the cap and turn the zero adjustment as necessary to SET the pointer at EMPTY.

4. Check the full-scale reading. Loosen the STOP NUT screw and screw the EMPTY bellows stop downward. Then loosen the screw and rotate the FULL bellows stop to allow free movement of the knife-edge bearing (illustrated). Loosen the safety valve mounting screw, push the valve up out of the way, and use a Model 80 test indicator or water column to apply full-scale pressure. If the pointer registers FULL, the indicator is accurately adjusted.

5. Position the linkage. Loosen the lock nut at the top of the spring stud and turn the stud until the knife-edge bearing is horizontal. Then detach one end of the link and run the sector gear off the pinion in the direction which opens the hairspring. Give the pointer shaft 1/2 turn to close the hairspring and hold it while you re-engage the sector. Connect the link and check tension and coiling of the spring.

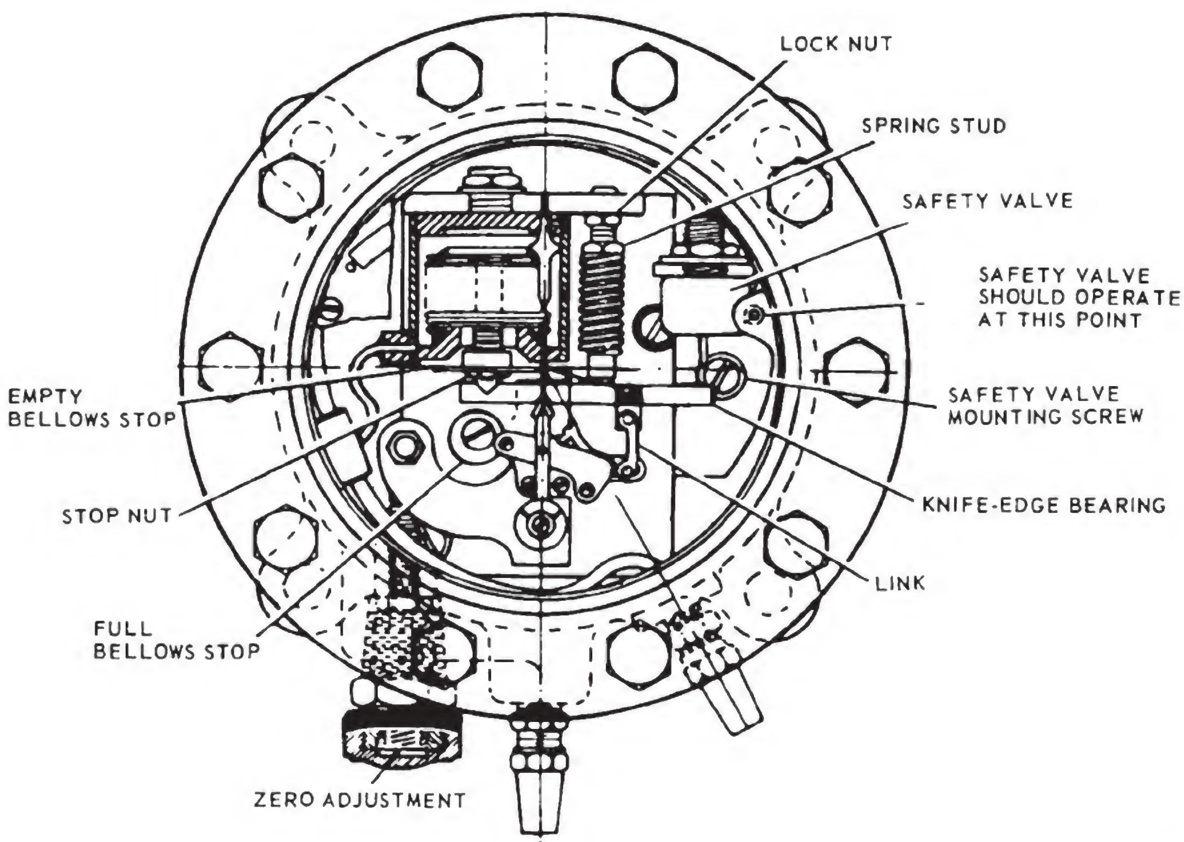
Place the link in the vertical position and turn the zero adjustment to both extremes. Observe the positions of the pointer and set the zero adjustment at its midpoint. Remove the pointer and replace it at the 12 o'clock position and tap it onto the shaft. Then turn the spring stud until the pointer is on EMPTY and tighten the lock nut at the top of the spring stud.

6. Adjust the indicator. First, apply full-scale pressure and observe the position of the pointer. Release the pressure and shorten or lengthen the stroke, as necessary, by moving the bottom of the link OUT or IN, respectively. Then position the pointer at EMPTY with the zero adjustment, if possible; otherwise, pull the pointer and set it at EMPTY. Apply full-scale pressure and repeat the preceding adjustments, as required.

7. Set the stops. Set the safety valve by applying sufficient pressure to bring the pointer opposite the right-hand dial screw hole. Then loosen the safety valve mounting screw and raise or lower the valve until it operates when the pointer reaches this position. Tighten the screw and rotate the FULL bellows stop until it checks further movement of the knife-edge bearing when the pointer reaches a position 1/8 inch beyond the point where the safety valve operates. Move the pointer slightly below EMPTY by depressing the right end of the knife-edge bearing and screw IN on the empty bellows stop until it prevents further movement of the pointer just before the pointer hits the side of the case on the empty side. Then replace the cover assembly and recheck the stroke adjustment.

8. Pressure-test the indicator. Replace a cracked or scratched lens. Then install tubing and fittings so that compressed air can be applied from a common source to the indicator's equalizing line and measuring line fittings when the indicator is submerged under water.

Immerse the indicator in water and apply compressed air, 300 psi for Model 10-1 or 500



91.332

Figure 12-2.—Adjustment of a Model 10 indicator.

psi for Model 10-2, and watch for bubbles (indicating leaks) in the housing, zero adjustment, fittings, around the lens, and so forth.

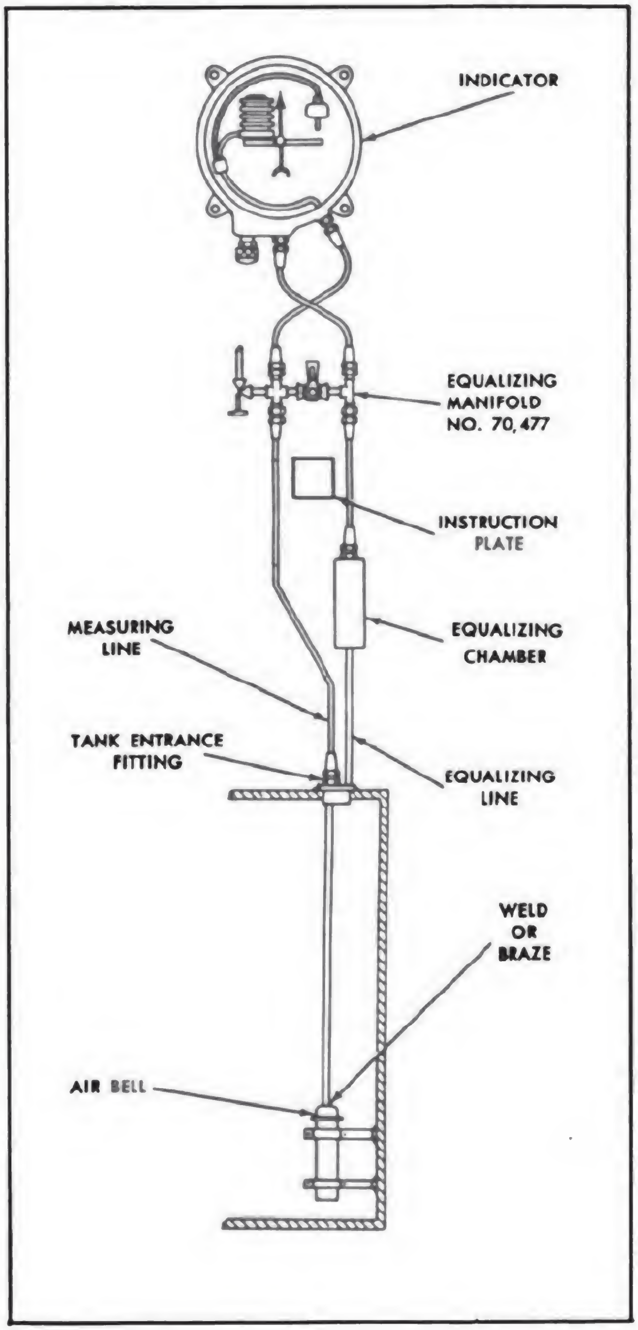
Attach the indicator to a simulated tank such as the one shown in figure 12-3, but with an air bell in an 8 inch pipe about 4 feet long. The air bell MUST BE pressure-tight and leakproof. (The purpose of the water is to apply greater pressure to one side of the indicator bellows.) Then turn the equalizing valve at the center of the manifold to the OPEN position and open the air intake valve at the left of the manifold for about 10 seconds. Close the equalizing valve, then the air valve, and wait for the pointer to come to a rest position. Note the reading; then repeat the procedure a few times.

If the pointer readings vary, readjust the indicator and set the stops and repeat the pressure test. If the pointer gives readings consistent with the first pressure test, check the stroke setting. If the adjustment has NOT changed, the indicator is satisfactory. If the adjustment has changed, readjust it, set the stops, and again apply pressure. Check the indicator adjustment. If it has changed, the bellows is defective and the indicator must be overhauled.

ADJUSTMENTS (ALL MODELS EXCEPT NO. 10)

There are two operations to the adjustment procedure (calibration) of all hydrostatic gages except No. 10: (1) setting the stroke, and (2) testing the pressure. Steps in the process are:

1. Mount the gage on a set-up board, as illustrated in figure 12-4.
2. Fill the glass column used on the test board with sea water to the height (feet and inches) which the gage is supposed to register, in accordance with the aepth of the tank (inapplicable aboard ship).
3. Set the pointer of the gage on EMPTY (zero adjustment, fig. 12-2).



91.333
Figure 12-3. —Typical installation of a Model 10 indicator.

4. Connect the measuring line (fig. 12-5) to the gage and check the stroke from EMPTY to FULL by opening and closing the vent petcock. Pump the gage until the pointer registers EMPTY with the petcock closed and FULL with the petcock open.

5. If the stroke is short of FULL, move the link from right to left and repeat step 4 after each adjustment.

6. If the stroke is past FULL, move the link from left to right and repeat step 4 after each adjustment.

7. Remove the dial from its case and adjust the safety valve by moving it AWAY FROM or CLOSER TO the knife-edge bearing.

8. So adjust the pointer that it reaches the side of the case near the FULL position and stops inside the case at the EMPTY position.

9. Replace the dial, set all stops, and repeat step 4 to determine whether the stroke is still accurate.

Test the pressure on levelometer gages (except Model 10) in the following manner:

1. Connect the measuring and equalizing lines to the gage.

2. Turn the equalizer valve to OPEN and open the air valve for about 10 seconds.

3. Close the equalizer and air valves and take a gage reading when the pointer stops. Repeat this test several times, with the tank vent valve OPEN and with it CLOSED.

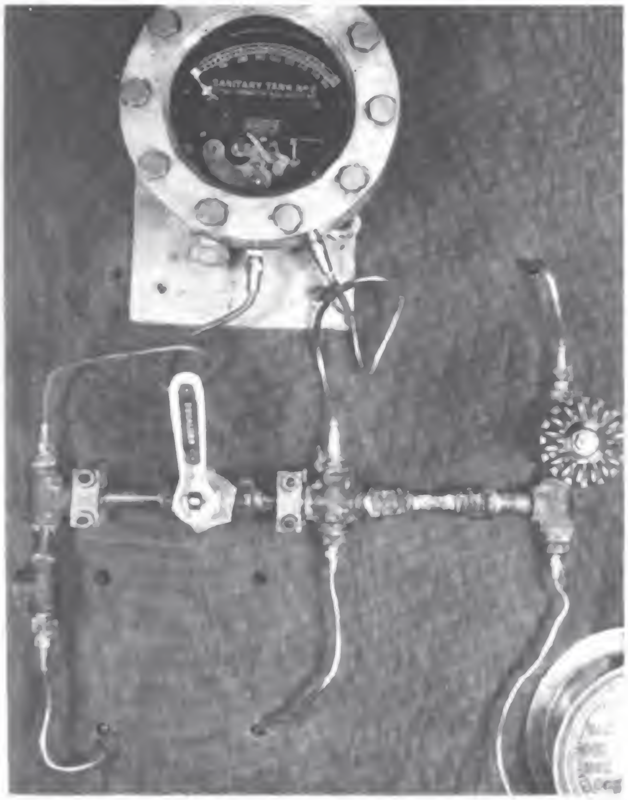
4. If all the readings are the same, open the vent valve and disconnect the measuring and equalizing lines.

5. Recheck the stroke. If it has CHANGED, reset the stroke and retest for pressure.

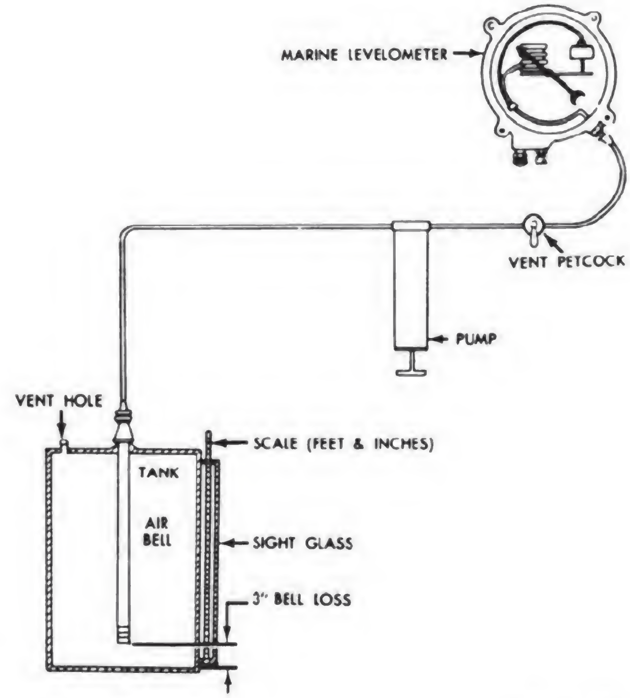
LIQUIDOMETERS

The tank unit in a hydraulic gaging system (liquidometer) is connected to the indicator by two capillary tubes filled with kerosene and encased in rigid copper conduit throughout most of their length. Flexible or braided conduit is used for making connections. The capillary tubes are usually pumped with a vacuum and filled with kerosene at the factory, or by the naval activity responsible for assembly of the gaging system. Later in this chapter you will learn how to fill the system with a portable filling apparatus, as you must do when you overhaul liquidometers.

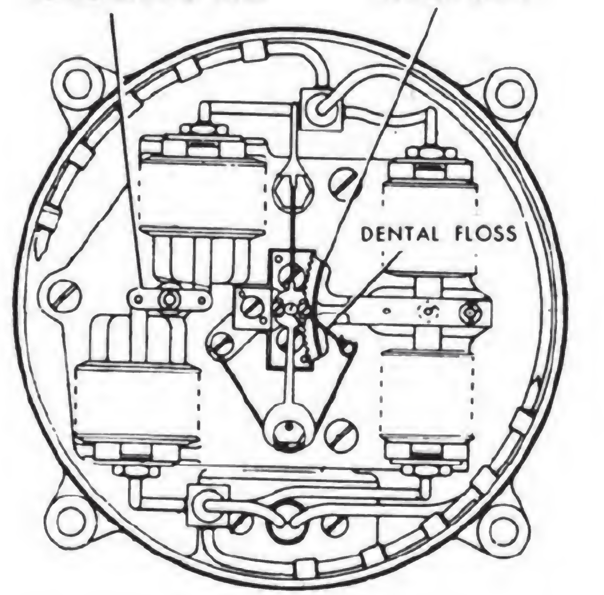
Hydraulic gaging systems do NOT require periodic maintenance, but difficulties must be corrected as they occur. The procedure for doing this follows.



91.334X
Figure 12-4.—Set-up board for calibrating levelometers.



91.335X
Figure 12-5.—Schematic arrangement for setting the stroke.



91.336
Figure 12-6.—No. 2602 mechanism in neutral.

INDICATOR MECHANISM

Inspect the indicator mechanism and make essential repairs. Check particularly for:

1. A bent pointer or shaft. Remove the indicator cover and pointer and loosely position the pointer on its shaft. Then rotate the pointer to ascertain whether its clearance with the dial is 1/8 inch throughout its travel. If the pointer or shaft is bent, straighten it; if either one is badly damaged, replace the indicator mechanism.

2. Binding of the pointer shaft. Apply oil to eliminate binding. If an application of oil does not eliminate the binding, install a new mechanism.

3. Dirt in gears, or binding linkage. Clean and oil these parts with light machine oil.

4. Dental floss (in No. 2602 or No. 4007 mechanisms), or broken or fouling pointer shaft. See figure 12-6. Remove the old dental floss from the mechanism and replace the spring, if it is defective. Then select a piece of dental floss 10 inches long and knot one end. Thread the unknotted end of the floss through the hole in the pointer shaft and pull it up to the knot. Wrap the

dental floss around the pointer shaft two or three turns, counterclockwise, and observe whether the spring pulls the pointer toward EMPTY. Then run enough of the free end of the dental floss through the eye of the spring to keep the spring under tension and tie the floss with a single knot.

Actuate the stroke lever of any tank unit to determine whether the spring exerts tension on the pointer shaft throughout the entire travel of the pointer. Then adjust tension of the spring, as necessary, by bringing the CORRECT amount of dental floss through the spring eye.

5. Other defects. Inspect the indicator mechanism for a fractured or leaking bellows, indicated by kerosene in the case, and also for any other defects. If you cannot remedy defects, replace the indicator mechanism.

TANK UNIT

When you inspect the tank unit, include the:

1. Tank unit housing. On internally-mounted units, the housing must be secured to the mounting bracket, which must be properly installed. On externally-mounted units, the fulcrum pipe must be screwed securely into the housing. You can tighten it with a wrench after you remove the float arm and disconnect the adjustment block assembly.

2. Adjustment block assembly. The stroke adjustment block must NOT be jammed on the stroke lever by the top of the pointer adjusting screw. If such is the case, loosen the lock nut and lock screw and unscrew the pointer adjusting screw. Then reinstall the screw and check for binding of the stroke adjustment block. If it still binds, cut about 1/8 inch from the top of the pointer adjusting screw.

3. Stroke lever. (On some tank units the stroke lever is part of the transmitter.) If the lever is bent, replace the assembly to which it belongs. A filled transmitter can be connected under kerosene at the coupling box.

4. Pins and bearings. The main pivot should have .005 inch play. If a fit is binding or sloppy, install a new pivot. Eliminate noise caused by side play with a suitable shim. If a pin is loose or binds, replace it with a new one.

5. Float arm and float. A float arm must have correct length, in accordance with specifications, and must not be loose at either end. Install new pins or bolts and nuts with lock washers, as required. A float arm may be bent slightly or shortened to clear an obstruction provided it still hits the float stops and does not make an angle greater than the allowed tolerance. A float or float arm must not hit a bulkhead or be hindered in its action in any manner.

If a float arm is bent, check the installation drawing to find out if the bending was intentional or accidental. Replace a crushed or damaged float. Check the float for leaks or adjust for weight.

TRANSMISSION SYSTEM

Move the float from EMPTY to FULL and observe the total stroke traveled by the position of the pointer, at both extremes. Then check the results against the tolerances for specific models for multiple-step systems, as follows:

Model	Length of Stroke	Pointer Position
25	1/8 inch	1/4 inch
35,45,55,65	1/4 inch	1/2 inch
75	5/8 inch	1 1/4 inches

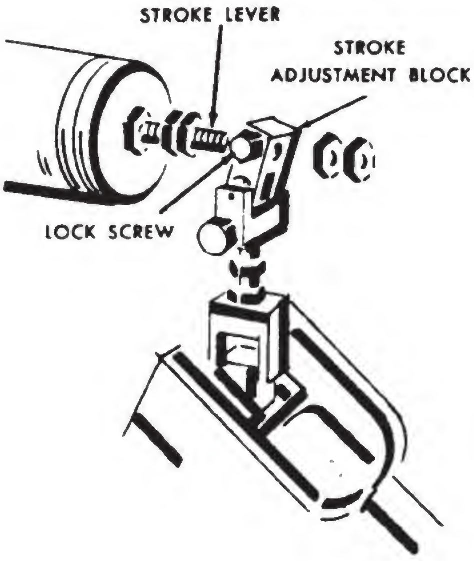
If the pointer stroke and position are both within the tolerances but slightly inaccurate, proceed as follows to adjust the gage:

1. Turn the pointer to the correct position with the pointer adjusting screw. On a multiple-step system, divide the necessary adjustment among all steps in the system.

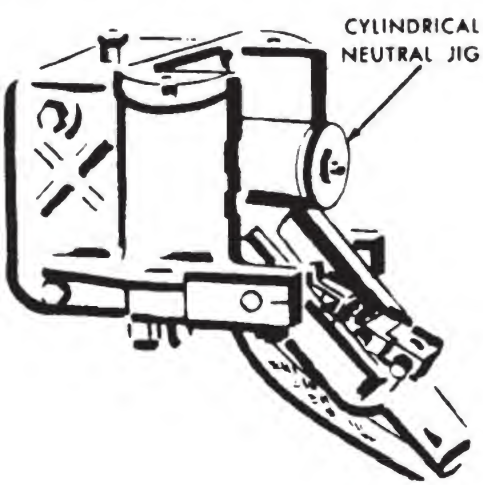
2. Set the stroke by moving the stroke adjustment block in or out on the stroke lever (fig. 12-7). On a multiple-step system, set the stroke for each step by the stroke-setting dots (explained later) on the dial.

If the pointer's stroke or position was not within the tolerances given, neutralize the transmitters and determine whether the indicator mechanism is in neutral. The procedure for putting the transmitters in neutral varies for different tank units. For units No. 31700, No. 5700, or No. 5708, disconnect the float arm linkage as illustrated in figure 12-7 and install a cylindrical neutral jig on the stroke lever (fig. 12-8). You can make a neutral jig in accordance with instructions in the manufacturer's technical manual. Check this manual also for the procedure for putting the transmitters of all other tank units in neutral.

The next step is to determine whether the indicator mechanism is in neutral. Remove the



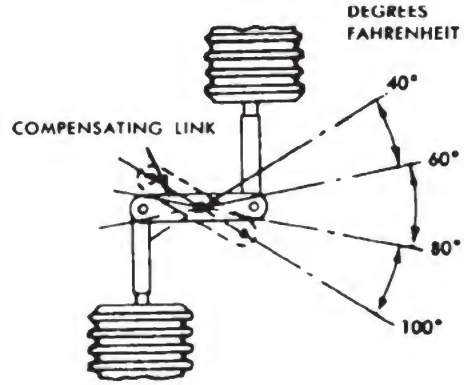
91.337
Figure 12-7.—Disconnecting the float arm linkage on an internal-mount tank unit.



91.338
Figure 12-8.—Neutral jig installed on the stroke lever of an internal-mount tankunit.

cover assembly (also dial on some indicators) and proceed as explained next to determine whether the mechanism is in neutral.

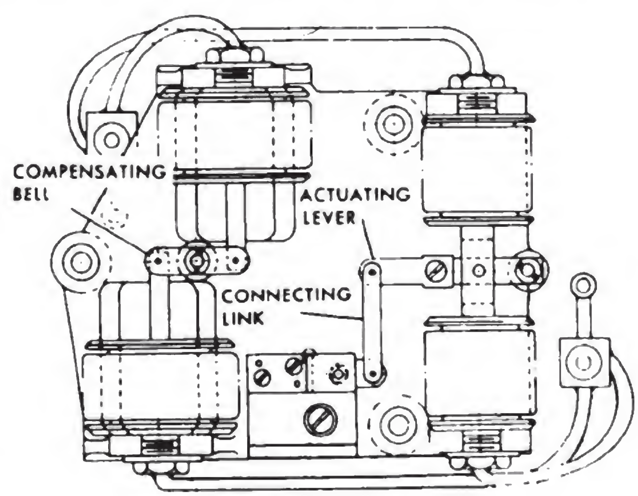
1. On indicators with the No. 2602 mechanism (fig. 12-6), the sector gear should be centered approximately on the pinion and the compensating link should be approximately at the angle which corresponds to the temperature, as given in figure 12-9. This is an approximate measure, as an allowance is necessary for



91.339
Figure 12-9.—Temperature setting for the compensating link.

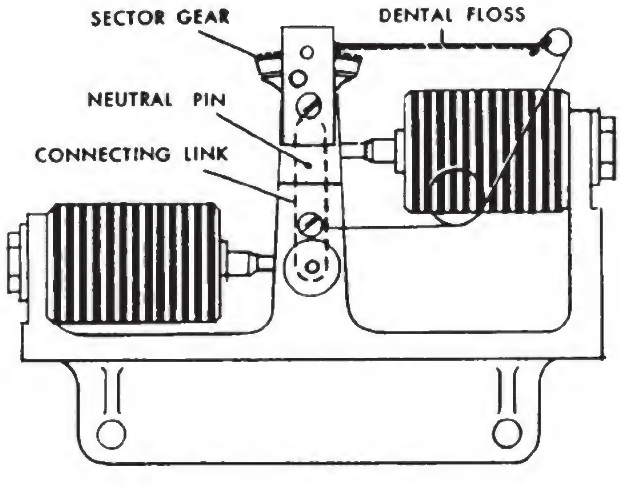
temperature variations throughout the system, length of transmission tubing, number of steps, and so forth.

2. On indicators with the No. 2413 mechanism illustrated in figure 12-10, the actuating lever should be horizontal, as shown; and the compensating link should be approximately at the angle which corresponds to the temperature.



91.340
Figure 12-10.—No. 2413 mechanism in neutral.

3. Indicators with the No. 4007 mechanism (fig. 12-11) should have the sector gear approximately centered on the pinion, and the connecting link between the bellows should be about at the angle corresponding to the temperature. If the indicator mechanism is not in



91.341
Figure 12-11.—No. 4007 mechanism in neutral.

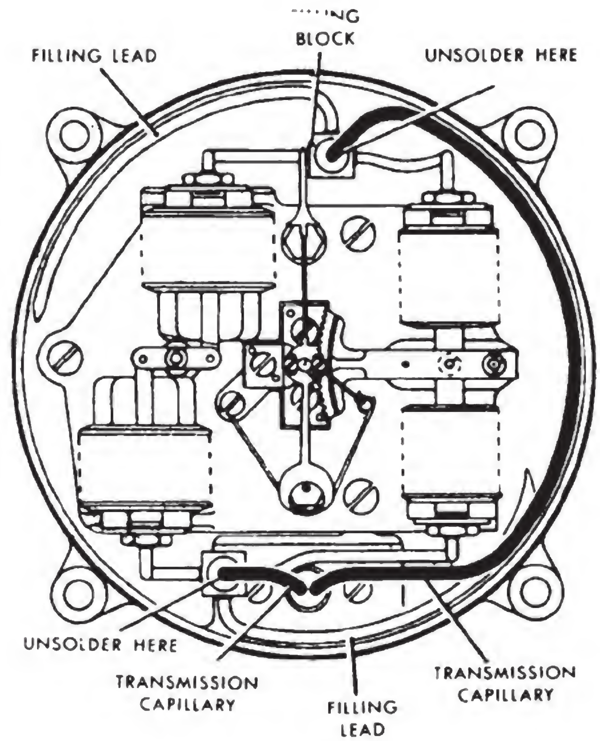
neutral, replace the mechanism. If the mechanism is in neutral but the pointer is not at the neutral position, remove the pointer and position it at neutral.

With the pointer and the mechanism both in the neutral position, actuate the stroke lever of any tank unit transmitter to ascertain whether it has a SOLID feel, except for play in the pins. If the stroke lever feels SPONGY, air bubbles have entered the transmission system and the gage must be overhauled. If the transmission system is satisfactory, connect the transmitters and neutralize and adjust the gage.

REPLACING AN INDICATOR MECHANISM

To replace the mechanism of an indicator, do the following:

1. Unsolder the transmission capillaries in the indicator case (fig. 12-12). These capillary tubes connect with the main transmission line.
2. Unscrew and remove the mechanism and install an overhauled or a new mechanism.
3. Test the pressure in the main transmission line and then resolder the transmission capillaries to the indicator. If the filling leads are too short, solder new filling block assemblies to the mechanism.
4. When circumstances require that a completely new indicator be installed, including the case, remove the old indicator and install the new one. To uncouple a filled line without losing the fill, disconnect the couplings of the line under kerosene.



91.342
Figure 12-12.—Removal of the indicator mechanism.

REFILLING A HYDRAULIC SYSTEM

The following instructions are for filling a liquidometer with a portable filling set. For filling purposes, the indicator with the attached main transmission line is considered as one unit and the tank unit transmitter is considered as another unit. If the main line is more than 125 feet long, it must be filled in sections; and each section is considered as a unit. On a multiple-step installation, each transmitter is considered as a separate unit, as is the octopus (fig. 12-13).

Illustration 12-13 shows the procedure for filling a multiple-step system with prefilled transmitters. The method to follow when the transmitters are not prefilled is shown in figure 12-14.

The filling set has a filling manifold, which permits simultaneous filling of four units. If a system has more than 4 units, fill 4 units at a time until the task is completed. Then connect the units.

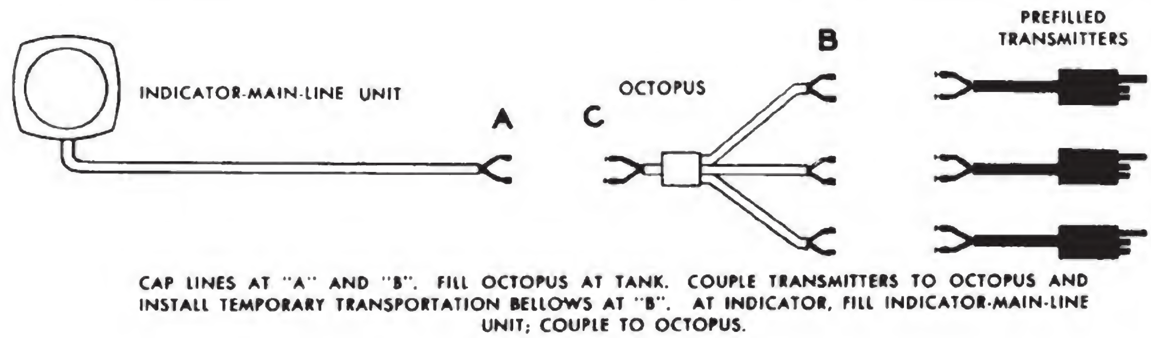


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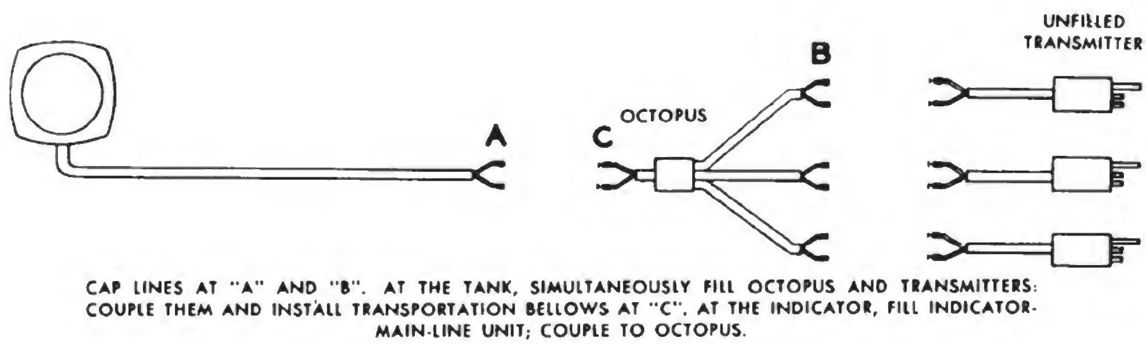
Figure 12-13.—Method of filling a multiple-step system with prefilled transmitters.



91.344

Figure 12-14.—Method of filling a two- or three-step system when the transmitters are not prefilled.

The schematic diagram of a filling set is illustrated in figure 12-15. Study it carefully, and refer to it as you study the filling procedure.

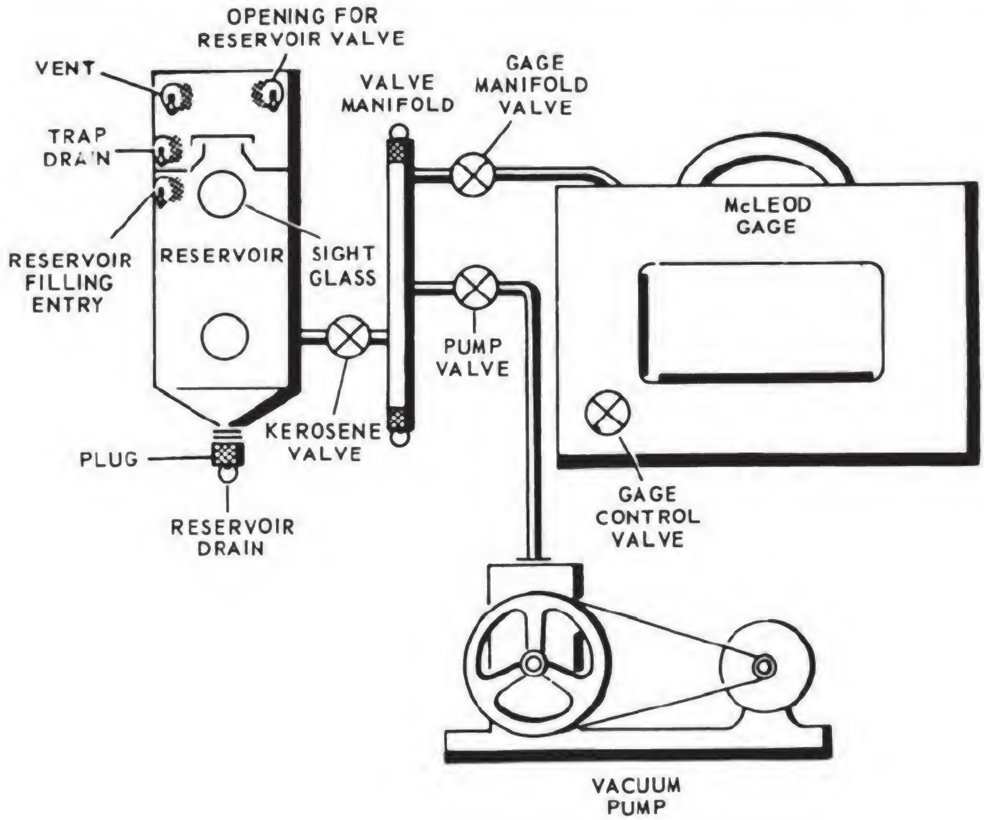
A filling set has the following major components:

1. Kerosene reservoir (for filling the system)
2. McLeod gage (for reading the degree of vacuum in microns)
3. Vacuum pump
4. Valve manifold: (a) gage manifold valve for opening and closing the line to the McLeod gage; (b) pump valve for opening and closing the line to the vacuum pump; and (c) the kerosene valve for admitting kerosene into the units after the air has been removed from them.

The upper part of the reservoir (fig. 12-15) is a trap for catching excess kerosene or condensates. Note the three capped openings on the left, and also the capped opening on the right. The vacuum pump is attached to the pump valve by the metal vacuum pump hose assembly, except during the evacuation of vapors from the kerosene. When the kerosene valve is closed and the pump valve, gage manifold valve, and the gage control valves are open, the pump creates a vacuum in the McLeod gage and in the units being filled. When the pump valve, gage manifold valve, and gage control valves are closed, with the kerosene valve and the reservoir vent open, atmospheric pressure enters the vent and forces kerosene into the units being filled.

Readings on the McLeod gage are taken by observing the height of a column of mercury—the higher the column, the lower the micron reading (indicating nearly perfect vacuum). To read a McLeod gage, proceed as follows:

1. Open the gage manifold and gage control valves and rotate the gage to the vertical position.
2. After the mercury stops rising, the column at the left of the reading column (center) should be at zero. If the column at the left of the reading column is not at zero, tilt the gage as necessary to bring it to this position. Then adjust the stop screw on the swivel neck to stop the gage at this position.



91.345

Figure 12-15.—Schematic diagram of a filling set.

3. Take the micron reading from the scale adjacent to the center column.

4. Return the gage to the horizontal position. CAUTION: Do NOT let the mercury remain lodged in the center column; and do NOT release mercury from the gage when it is in the vertical position.

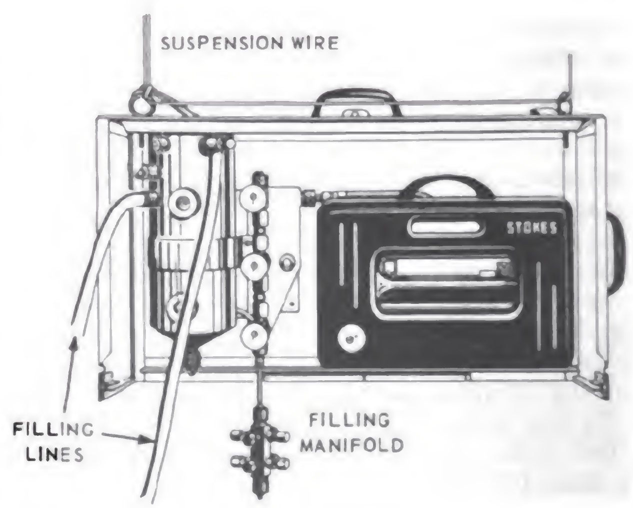
Preparing a Filling Set for Use

When you get a filling set ready for filling a hydraulic gaging system, follow this procedure:

1. Hang the set at a convenient location and remove the front and bottom panels and the support rod across the bottom. Study figure 12-16.

2. Place the vacuum pump within 6 feet of the filling set and change oil in the pump, in accordance with instructions on the plate on the pump housing.

3. If necessary, replace the O-rings on the valve stems, plug assemblies, and hose ends.



91.346

Figure 12-16.—Portable filling set with front and bottom panels removed.

NOTE: Except when in storage, change the O-rings on the valve stems once per month. Coat the rings with high-vacuum grease whenever they are dry; replace them if they have FLAT spots.

4. Tighten the 10 hexagonal (HEX) nuts, 7 on the valve manifold and 3 on the McLeod gage.

5. If necessary, fill the gage with mercury. Then check the gage for leaks.

6. Check the valve manifold, the reservoir, and the filling manifold for leaks. Review illustration 12-16.

Filling Procedure

To fill a single-step hydraulic gaging system, do three things: (1) evacuate the kerosene; (2) fill the indicator-main-line unit (tank unit), if it was not prefilled; and (3) couple the tank unit to the main line. The procedure for filling a multiple-step gaging system is more complicated, as you will learn by studying the following procedure for filling a five-step system:

1. Evacuate the kerosene, fill the octopus and the transmitters for steps 1, 2, 3, and couple these 4 units.

2. Evacuate the volatile components and dissolved air from the kerosene, as follows:

a. Install a reservoir valve assembly in the opening (fig. 12-15) and connect a vacuum pump to the reservoir valve with 6 feet of neoprene hose.

b. Close the valve and start the pump; then open the pump and reservoir valves and run the pump 2 hours.

c. Close the reservoir valve.

d. Remove the neoprene hose and connect the vacuum pump to the pump valve with metal hose.

e. Change oil in the vacuum pump.

3. Evacuate the octopus and the three transmitters, as follows:

a. Cap the octopus lines at the transmitter ends.

b. Couple the appropriate filling leads to the filling manifold, main-line end of the octopus, and the 3 transmitters (fig. 12-17).

c. Close all valves and start the pump; open the pump and gage manifold valves and operate the pump approximately 2 minutes; then open the gage-control valve.

d. Run the pump about 1/2 hour and make a preliminary test of the vacuum. Close the pump valve to turn the pump off, take a reading, wait 5 minutes, take a second reading, and determine whether the difference between the readings is 100 microns or less. If this difference is greater than 100 microns, repeat the test; if the difference is then greater than 100 microns, check for leaks or vapor in the lines.

e. Start the pump, open the pump valve, and pump for at least 2 hours.

f. Close the pump valve to turn the pump off and determine whether the reading is now 25 microns or less. Wait 5 minutes and take a second reading. The difference between these readings should be 25 microns or less. If the test is NOT satisfactory, start the pump and open the pump valve, gage manifold valve, and the gage control valve and operate the pump 1 hour. Then repeat the test until the desired reading is obtained and close ALL valves.

4. Inject kerosene into the units:

a. Open the kerosene valve, remove the plug from the vent, and allow 2 hours for the vacuum to draw kerosene into the units being filled.

b. Slowly operate the stroke lever of the step 1 transmitter UP and DOWN a few times.

5. Connect the transmitters to the octopus:

a. Neutralize the step 1 transmitter by inserting a neutral pin, in accordance with the manufacturer's instructions.

b. On an internal-mount tank unit, install a neutral jig.

c. With closing-off pliers, squeeze the two filling leads to the No. 1 transmitter just below the filling manifold (fig. 12-17).

d. Make enough consecutive squeezes on the leads (toward the manifold) to flatten a section 1/4 inch long.

e. With cutting pliers, cut off both filling leads BELOW the flattened section. CAUTION: Do NOT cut leads between the flattened section and the filling manifold.

f. To avoid spilling kerosene, raise the ends of the other filling leads on the transmitter.

g. Place the octopus leads for step 1 under kerosene, remove the filling leads from the No. 1 transmitter capillaries (under kerosene), and locate capillaries with P STAMPED ON the male and female fittings.

h. Bleed the octopus P capillary for about 5 seconds until bubbles stop.

i. Couple the P fittings with new copper washers lightly coated with high-vacuum grease.

j. Bleed and couple the 2 unmarked fittings in the same way.

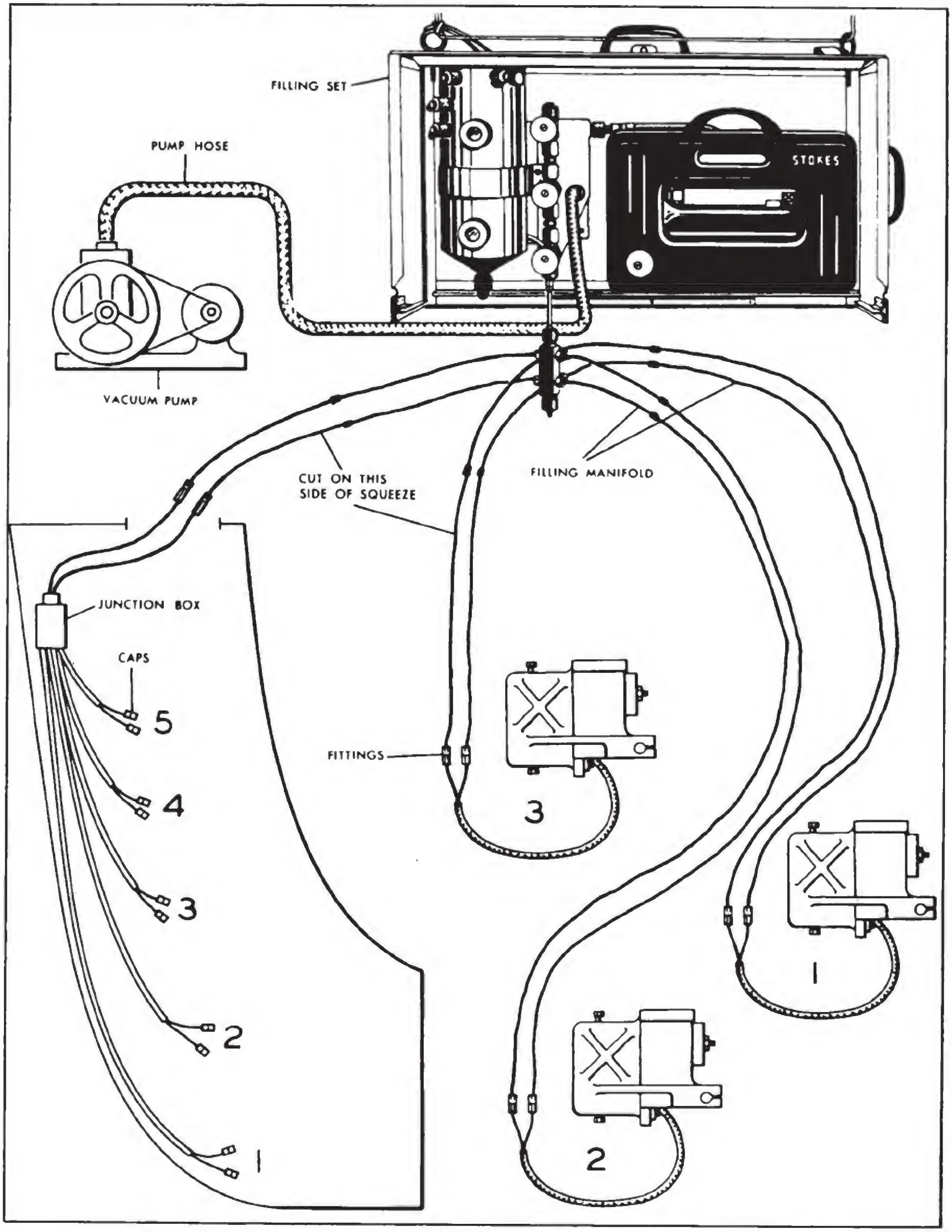


Figure 12-17.—Connections for the first filling. 91.347

k. Bleed the octopus lines for steps 4 and 5.

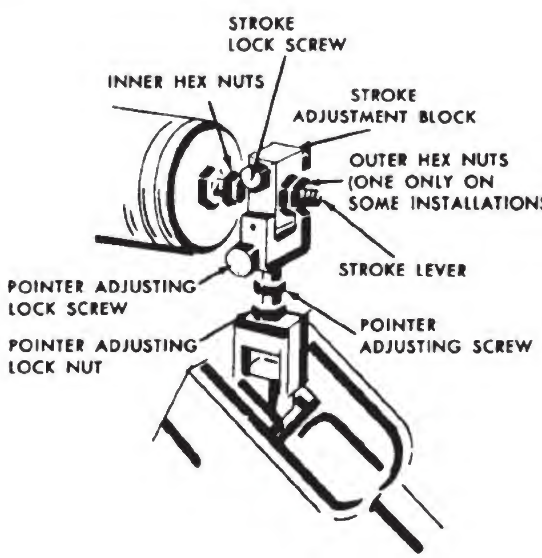
l. Squeeze the two filling leads to the octopus JUST BELOW the filling manifold.

m. Close the kerosene valve and immerse the octopus leads under kerosene and remove the filling leads.

The second filling of a multiple-step hydraulic gaging system consists of evacuating the kerosene, filling the indicator-main-line unit and the remaining TWO transmitters, and coupling all units. Study the details for making the second filling in NAVSHIPS 387-0276.

ADJUSTING A HYDRAULIC GAGING SYSTEM

After you repair or install a hydraulic gage, adjust the pointer so that it travels from EMPTY to FULL as the float moves from one extreme to the other. Use an adjustment block to make this adjustment. Study figure 12-18. NOTE: Some tank units have two adjustment block assemblies, one for each indicator.



91.348

Figure 12-18.—Stroke and pointer adjustments on a liquidometer.

Two types of adjustments must be made on hydraulic gages: (1) the STROKE, or distance traveled by the pointer; and (2) the POSITION of the pointer.

ADJUST THE STROKE by moving the stroke adjustment block IN or OUT, as necessary, on the stroke lever. If you move the adjustment block OUT, you decrease the stroke; when you move the adjustment block IN, you increase the stroke.

ADJUST THE POINTER with the pointer adjusting screw. Loosen the lock nut at the bottom of the screw and also the pointer lock screw, make the adjustment, and tighten the lock nut and the pointer lock screw.

Single-step System

To adjust a gaging system with a single indicator, do the following:

1. Slowly raise the float from the bottom to the top of the tank (lower stop to upper float stop) to determine whether the distance traveled by the pointer is approximately equal to the distance between the EMPTY and FULL marks on the dial.

This is a preliminary ROUGH check. If the stroke is short or long, move the stroke adjustment block in or out until the stroke is approximately correct and then lock the adjustment.

2. With the float at the bottom position, the pointer MUST BE on the EMPTY mark. If it is not on this mark, use the pointer adjusting screw to position it on EMPTY and lock the adjustment.

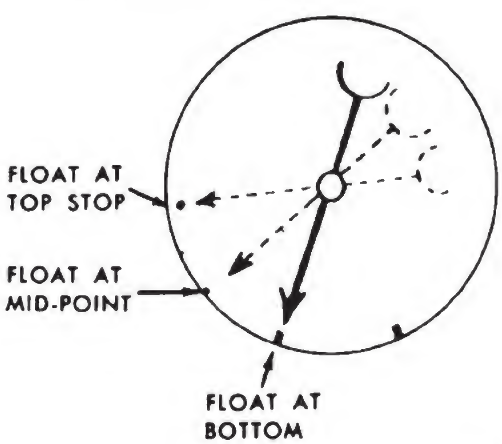
3. Slowly raise the float to the top of the tank and check the position of the pointer. If it is not on the FULL mark, estimate the number of flats (1/6 turn of the HEX nut on the stroke lever or the hexagonal part of the pointer adjusting screw) you should move the stroke adjustment block in or out and then slowly lower the float to the bottom of the tank and make the estimated stroke adjustment. Lock the stroke adjustment, position the pointer at empty, and lock the pointer adjustment.

4. Repeat step 3 and, if necessary, make further adjustments.

Multiple-step System

Before you adjust a multiple-step hydraulic gaging system, NEUTRALIZE each step—place all linkages at right angles when the float is at its midpoint of travel. When you have the gage correctly neutralized, the pointer action should correspond with the action of the pointer illustrated in figure 12-19, which gives the FIRST STEP in a multiple-step gaging system.

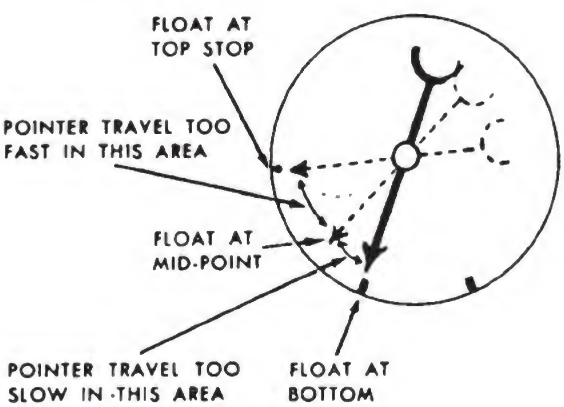
If the gage is not neutralized, you can still adjust it so that the pointer will be accurate when the float is at the UPPER or LOWER



91.349
Figure 12-19.—Pointer action on a correctly neutralized gage.

limit. See figure 12-20. As indicated in this illustration, however, the pointer will be inaccurate when the float is near its MIDPOINT.

When you adjust a multiple-step gaging system, you need a dial with stroke-setting dots like those shown in figure 12-21, and neutralizing marks like those illustrated in figure 12-22. If an adjustment dial with stroke-setting dots and neutralizing marks is provided with the indicator, you are ready to proceed with the adjustment.



91.350
Figure 12-20.—Pointer action on a gage incorrectly neutralized.

When necessary, you can make a dial with stroke-setting dots in the following manner:

1. Check the installation drawing to find out the percentage of pointer action covered by each step.

2. Divide the total pointer travel in proportion to these percentages. Total pointer travel is 336° on a Model 75 gage and 300° on Models 45, 55, and 65.

3. Prepare a temporary dial with end marks 300° or 336° apart, and with dots indicating the limits of pointer travel covered by each step (fig. 12-21).

Do the following to prepare a dial with neutralizing marks:

1. Place the dial with stroke-setting dots on a piece of paper.

2. Draw lines from the center of the dial through the end marks, and through the dots representing the limits of each step. Extend the lines about 1 inch beyond the edge of the dial.

3. Use a protractor to determine the number of degrees in each step.

4. Enter at the top of a blank paper dial each step, as shown in figure 12-22, with half of each step on each side of the center line. Then number the steps.

NEUTRALIZING PROCEDURE.—The procedure for neutralizing a gaging system follows:

1. Put the dial with neutralizing marks on the indicator.

2. Tie each float arm in the neutral position—midpoint of its travel. If the float arm guides have neutral holes, insert a 1/2 inch pin through the holes and rest the float arm on the pin.

3. If the pointer is NOT on the center line of the dial, turn the pointer adjusting screw as required to bring the pointer to the line.

4. Release the float on the lowest tank unit and lower it slowly to the bottom float stop. If the pointer is not then on the left-hand mark for step 1, lengthen or shorten the stroke, as necessary, with the stroke adjustment block to bring the pointer on line.

5. Slowly raise the float to the upper stop. If the pointer is not then on the right-hand mark, estimate the number of flats you must move the stroke adjustment block IN or OUT. Then slowly lower the float to the bottom float stop, make the estimated adjustment, and align the pointer with the mark.

6. Repeat the last step and, if required, make further adjustments. When the pointer is on the end marks for step 1 with the float at the upper and lower float stops, it WILL BE ON the center line when the float is at its midpoint.

7. Secure the bottom float in the neutral (midpoint) position and release the float for

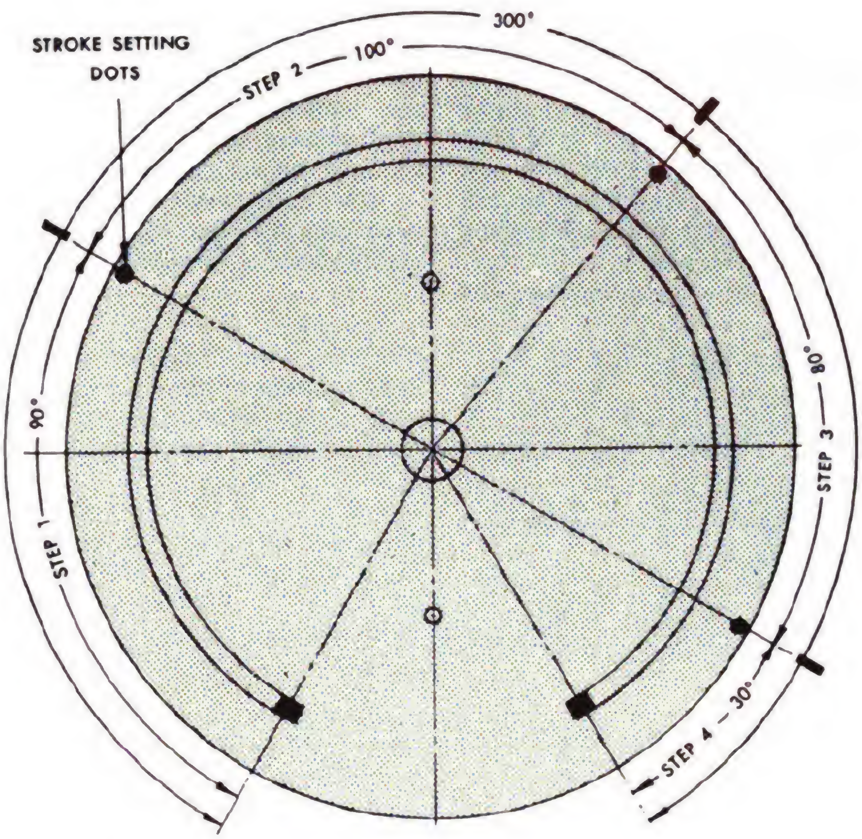


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Figure 12-21.—Dial with stroke-setting dots.

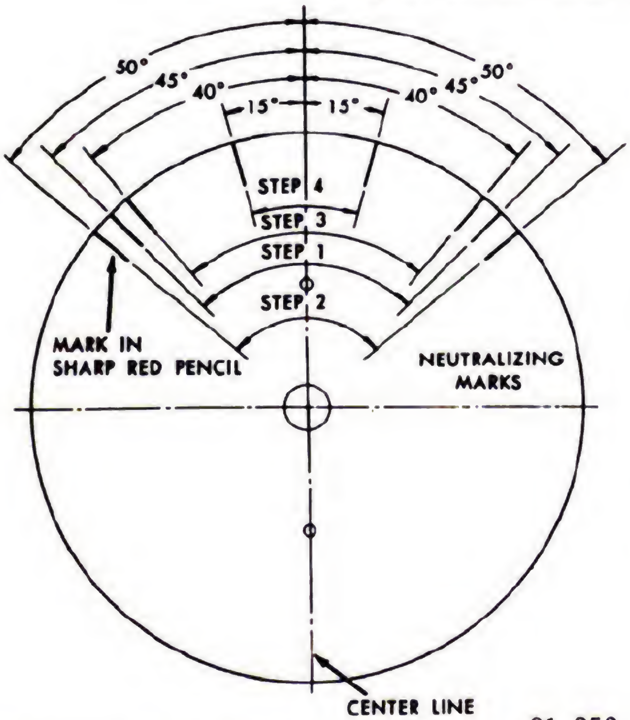

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Figure 12-22.—Dial with neutralizing marks.

step 2. Connect the linkage for step 2 ONLY, by removing the neutral jig and connecting the adjustment block assembly on internal-mount units, or by connecting the transmitters to external-mount tank units.

8. Repeat steps 3 through 7 for the step 2 tank unit, using the neutralizing marks for step 2. After you neutralize the second step, secure its float at the neutral position and repeat the neutralizing operation for the remaining steps in the system. After you neutralize all steps, lower all floats to their bottom stops.

ADJUSTMENT PROCEDURE.—The steps in the adjustment procedure for a multiple-step gaging system are:

1. Install on the indicator a dial with stroke-setting dots.

2. When the float for step 1 is resting on the tank bottom or lower float stop, if necessary, position the pointer at the EMPTY mark.

3. Slowly raise the float to the upper stop. If the pointer is NOT on the dot which indicates the end of the first step, estimate the number

of flat strokes to move the adjustment block IN or OUT, lower the float to the bottom, and make the estimated stroke adjustment. Then lock the stroke adjustment.

4. Repeat step 3 and, if necessary, make further adjustments.

5. Tie the float to its UPPER float stop and repeat steps 2 through 4 for step 2 and tie the No. 2 float to its upper stop. Then adjust the succeeding steps in the same way.

6. After you adjust all steps, release the top float and slowly lower it to its bottom stop. Then check the position of the pointer at each extreme of the float's travel and continue with the remaining steps in the system. If any steps are inaccurate to a significant degree, repeat the adjustment procedure. When you complete the adjustment, tighten all lock screws and nuts.

For additional information on any phase of servicing or overhauling of levelometers and liquidometers, study NAVSHIPS 387-0276.

CHAPTER 13

DIAL INDICATORS—GAGES—TACHOMETERS

Some of the things you must understand and be able to do concerning the instruments listed in the title of this chapter before you can qualify for advancement in rating to an Instrument 1 are: (1) true pressure gage hairsprings in the flat and in the round, (2) fit replacements for defective bushings and plates, (3) recharge cylinders in gage comparators, (4) refill vacuum gage testers, (5) analyze and remedy casualties to all kinds of gages, and (6) explain the operating principle of different gage testers.

Additional things which you must understand about these instruments and be able to do concerning them before you can qualify for advancement in rating to a Chief Instrumentman are: (1) maintenance of gage comparators and tachometer testers; (2) operating principle of a loader valve in a gage comparator; and (3) the procedure for: calibrating dial indicators and aneroid barometers, colleting and studding barometer and dial indicator hairsprings, and replacing defective parts in and adjusting tachometers.

Before you study this chapter, review the chapters in Instrumentman 3 & 2, NavPers 10193-B, on gages and tachometers. An attempt is made in this chapter to hold to a minimum unnecessary repetition of information given about these instruments in those chapters.

DIAL INDICATORS

A dial indicator is a small instrument used for testing such things as the trueness of a gear, a sheave, or a wheel; and it can be used also for checking the exact height of objects, or the trueness of a shaft between centers. Study the procedure for doing this in Basic Handtools, NavPers 10085-A.

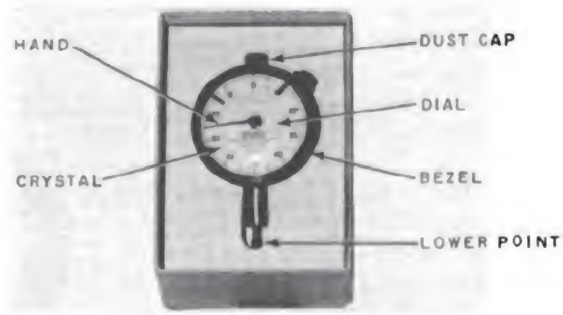

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Figure 13-1.—Front view of a Federal dial indicator.

GENERAL DESCRIPTION

There are various makes and types of dial indicators—Ames, Federal, Starrett—but their mechanisms are essentially the same. Study the dial indicator illustrated in figure 13-1. The graduation indicated on the dial of this indicator is .001 inch, but graduation and range will vary for different models. One group of indicators, for example, has graduations and ranges as follows (for different models):

Graduation	Range
.0001 inch	.025 inch
.00025 "	.025 "
.00025 "	.050 "
.005 "	.050 "
.001 "	.050 "
.005 "	.075 "
.0005 "	.100 "
.0005 "	.125 "
.001 "	.125 "
.001 "	.250 "

All dial indicators used in the Navy are made in accordance with the American Gage Design (AGD) standard and/or Navy specifications.

Their mechanisms are precision-built throughout, with jeweled or plain (bronze inserted, in some) bearings. The mechanisms are shockproof, sensitive, and accurate; and they are also rigid and rugged.

The gear train of a Federal dial indicator is shown in the case (back cover removed) in figure 13-2. Note the position of the parts and study the nomenclature. Gears and pinions are stainless steel. Another view of the mechanism of this indicator is illustrated in figure 13-3, with the rack removed. Controlled alignment of these gears permits perfect meshing, ensuring consistently accurate reading.

Disassembly and Reassembly

When you disassemble a Starret indicator with a rack and pinion, do the following:

1. Remove the back cover.
2. Line up the small hole in the bezel with the arrows on the bridge (with bottom stem for models 655 and 656) and insert a small pin in the .038 inch hole in the bezel (to compress the spring) and remove the bezel with a bezel remover.
3. Remove the movement by taking out the two plate screws which hold it to the case and then by lifting it out.

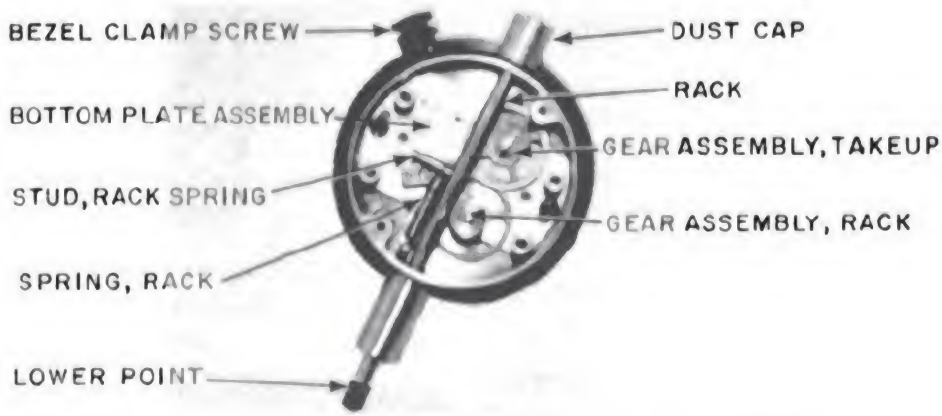

Figure 13-2.—Mechanisms of a Federal dial indicator in the case (back and top plate removed). 91.354

MAINTENANCE AND REPAIR

Maintenance and repair procedures for dial indicators vary somewhat with different manufacturers, as you will learn when you study their technical manuals for specific models.

Differences in the disassembly procedure for Starret dial indicators with non-shock mechanisms are indicated in the steps of the procedure:

1. Remove the stem cap and the stop screw.

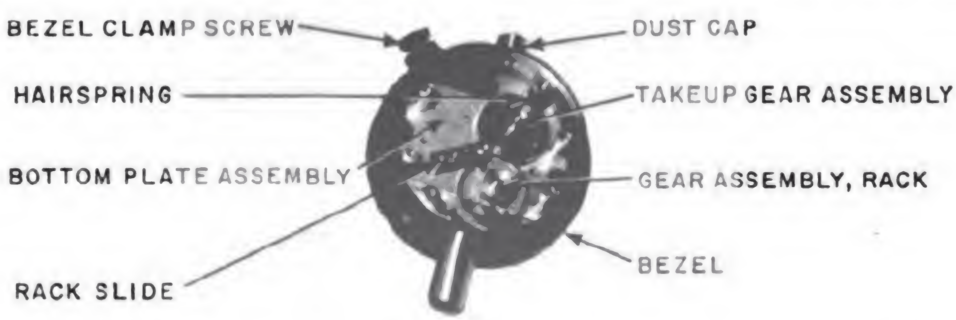

Figure 13-3.—Mechanism of a Federal dial indicator in the case (top plate and rack removed). 91.355

2. Remove the rack guide and then take out the rack guide pin with a small wrench.
3. Remove the screw in the spring stop collar, and (with tweezers) take out the pin under the shock spring washer.
4. Pull the spindle through the mechanism. NOTE: Observe the position of the springs.

The disassembly procedure for a Federal dial indicator is as follows:

1. Unscrew the back screws and lift the back off.
2. Remove the bezel screws, loosen the bezel clamp, and remove the bezel.
3. With screwdrivers, lift out the hand.
4. Remove the dial and dial spring.
5. Turn the case over and place it on a repair block.
6. Loosen the movement screws and rotate the movement counterclockwise in order to disengage it from the rack.
7. Unscrew and remove the dust cap.
8. Remove the rack stop screw. NOTE: On exposed-type indicators, remove the upper contact.
9. Pull the rack spindle down until the rack slide pin is free of the rack slide. CAUTION: Be sure to BUCKLE the spring outward.
10. Rotate the rack spindle as necessary to have the rack pin point OUTWARD and use tweezers to slip the spring off.
11. Unscrew the rack pin from the rack spindle. CAUTION: Do NOT mar the contact surface of the pin.
12. Completely withdraw the rack spindle.
13. Remove the movement screws and lift out the entire movement.
14. Remove the pinion.
15. Lift the spring off the rack spring stud, and remove the contact from the rack.

When you reassemble the non-shock mechanism of a Starrett dial indicator, insert the spindle through the following: bottom stem of the case, short leg of the rack sleeve, shock spring washer (hollow side first), shock spring, long leg of the rack sleeve, stop collar, return spring, and the top stem of the case. Then replace the end stop screw to hold the spindle in position and insert the stop collar screw and the spring collar pin. Replace the rack guide pin and put the rack guide in position. Then insert the screw which secures it to the case. NOTE: Oil all bearings and pivots when you reassemble a dial indicator; but do NOT over oil any part, and keep oil off the hairspring.

When you put the non-shock movement back into the case, tighten the hairspring about 1/2 turn (or as necessary) in order to get required tension and hold the tension by placing a finger on the hand pinion. Continue to hold the pinion while you put the movement in the case and mesh the rack with the rack pinion. Then replace the plate screws to hold the movement to the case. Replace the dial spring, the dial, and the hand. Hook the bezel over the two closest protruding ears and compress the third ear to snap the bezel on. Then replace the back.

Use the following procedure for reassembling a Federal dial indicator (with adjustments, as explained):

1. Replace the pinion in the centralizing bushing.
2. Put the movement in the case (bottom plate down). CAUTION: The rack slide must be on the left side of the case and the movement gears must mesh properly with the pinion.
3. Replace the movement screws but do NOT tighten them.
4. Rotate the movement counterclockwise.
5. Screw the contact into the rack and insert the rack spindle through the lower stem bushing, thence up into the movement.
6. Screw the rack slide pin into the rack spindle. CAUTION: Do NOT mar the contact surface of the pin; and screw the pin into the correct side of the spindle, so that the rack teeth can mesh with the movement gears.
7. Slip the spring over the rack slide pin.
8. Rotate the rack spindle as necessary to have the rack pin fit in the rack slide.
9. Push the rack spindle through the movement, and up through the upper bushing.
10. Replace the rack stop screw. NOTE: On exposed types of indicators, replace the upper contact.
11. Hook the spring onto the rack spring stud.
12. Rotate the movement as necessary to unmesh it from the rack and then apply tension, as follows:
    a. Turn the case over and lightly place the indicator hand on the pinion.
    b. Move the hand clockwise until it reaches its counter-balance; that is, where the hand returns slightly when released.
    c. Wind the hand clockwise 5 revolutions.
    d. Hold the tension you created by placing a finger on the side of the hand. Then turn the

case over and so rotate the movement that the gear teeth mesh with the rack teeth.

e. Remove the indicator hand and hold the movement lightly with the index finger.

f. Push the rack upward until the gear train runs freely. CAUTION: To prevent loss of tension you put on the movement, do NOT disengage the movement from the rack.

13. Tighten the movement screws.

14. Proper meshing of the rack with the gear teeth is important, because looseness can cause shearing of the teeth. If the teeth are meshed TOO tightly with the rack, binding results. Hold a rack gear spoke with tweezers and push the rack back and forth. Correct existing looseness by carefully rotating the movement clockwise; then tighten the movement screws and repeat the test. CAUTION: Do NOT make the adjustment too tight.

15. Lightly replace the hand on the center pinion and test the indicator for tension by pushing up on the spindle and observing whether the hand promptly comes to rest. If the action of the hand is uncertain, increase the tension by loosening the movement screws and resetting the tension. Then remove the hand again.

16. With a large screwdriver, securely tighten the movement screws and the rack stop screw.

17. Remove dust from the movement with clean, compressed air.

18. Replace the back and securely tighten the back screws. NOTE: If the screw holes do not line up, rotate the back 180 degrees.

19. Replace the dust cap and put the dial spring over the pinion.

20. Replace the dial and hold it down with an index finger or a dummy bezel, if available. Put the hand on the pinion and strike the hand squarely with a small, light hammer. CAUTION: Do NOT bend the pinion with a SLANTING blow.

21. Check the hand for tightness by pulling up on it. Then rotate the hand to check its clearance with the dial.

22. Replace the bezel and secure it with the screws.

Cleaning

The best way to clean the mechanism of a dial indicator is to remove it from the case, disassemble the parts and inspect them. Then clean reusable parts with approved cleaning solution. You can clean the parts in a cleaning machine in the manner outlined for cleaning other instrument parts, or you can clean them by hand. Rinse thoroughly and dry the parts after you clean them.

Repairing

When you repair a dial indicator, do the following:

1. Inspect all parts carefully, and discard broken or badly damaged parts.
2. Polish pivots before you reassemble the mechanism.
3. Check the cross arm on the center point for worn spots. Clean or replace it, as necessary.
4. Check the spiral. Place it in the hole and engage the cross arm. Wind the gear bridge 1/2 to 3/4 turn to remove BACK lash; then hold the gear as necessary to prevent unwinding and place it on the spiral, being careful to mesh the gear with the spiral in one operation. Then screw the bridge down securely.

If you need to install a new center point bridge in the inside case (some models), do the following:

1. Put the bridge in position and, on a good drill press, spot the bridge through the hole in the case with a .125-inch diameter drill.
2. Drill the bridge with a .120-inch diameter drill and ream the hole with a .125-inch diameter reamer. If the center point does not run smoothly after you accomplish the drilling and reaming, polish the holes in the case and in the bridge with a polishing compound.

NOTE: It is not necessary to remove the stem from some dial indicators when you repair them.

Review the procedure in chapter 8 of this text relative to the procedure for colleting and studding dial indicator hairsprings.

For additional information relative to repair and maintenance of dial indicators, study the manufacturers' technical manuals for specific makes and models.

GAGES

This section pertains to Barton differential pressure gages, aneroid barometers, and maintenance procedures for pressure gages. Barometers are also discussed in this section, because they are gages which measure atmospheric pressure.

BARTON PRESSURE GAGES

The Barton Instrument Company makes different types and models of differential pressure gages, to meet specific needs. The Model 200 gage is illustrated in figure 13-4.

The pointer on a Model 200 Barton gage travels through a 270° arc over a 6-inch dial, and scales are calibrated in uniform increments for measurement of differential pressure or the level of a liquid. Square root graduations are also available for direct-reading of flow rate; and special scales are available for indicating the quantity of fluid in tanks. The sensing element for this gage is a bellows capsule (discussed later).

The model 200 indicator is used for measuring the flow of water, steam, liquid levels, and liquefied gases stored at low temperature (including CO_2)—ammonia, nitrogen, helium, and hydrogen.

The case of the Model 200 gage is made of cast aluminum and is finished with weather-resistant resin paint. The cover glass is secured in the bezel with an O ring, which reduces the possibility of accidental breakage of the glass and acts as a seal BETWEEN the bezel and the case, ensuring a moisture-, fume-, and dust-free atmosphere for the indicating mechanism.

Indicating Mechanism

The indicating mechanism in a Barton Model 200 pressure gage is a precision-made, jeweled, rotary movement which transmits rotation of the torque tube through a gear and pinion to the pointer. Zero and range adjustments of the movement are accomplished by means of micrometer screws; and zero adjustments can be made without removing the scale plate or the pointer. To make range and linear adjustments, remove the scale plate first. Both the rotary movement and the pointer are fully protected from over-range in either direction.

Differential Pressure Ranges

The Model 200 Barton gage measures differential pressure from a minimum of 0-20 inches of mercury or water to a maximum of 0-50 psi. Ranges between 0-20 inches and 0-400 inches require a bellows 3 3/4 inches in diameter. Range springs are NOT interchangeable between bellows of different size.

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Figure 13-4.—Barton Model 200 differential pressure gage.

If desired, zero center ranges and positive and negative suppression may be procured. Ambient temperature limitations are from -60° F to +200° F.

Performance

The performance rating for the Model 200 Barton pressure indicator is as follows:

1. From 0-20 inches w.c. to 0-349 inches w.c., the performance rating is ±1/2 percent of the full-scale differential pressure.
2. From 0-350 inches w.c. to 0-50 psi, the performance rating is ±3/4 percent of the full-scale differential pressure.

Sensing Element

The model 199 Barton differential pressure unit is used as the sensing element for the Model 200 gage. See figure 13-5. Study the nomenclature of this unit carefully. It is an accurate and reliable sensing element which measures differential pressure under severe operational and environmental conditions. It is composed of a rupture-proof bellows unit assembly and a pair of pressure housings which enclose opposite sides of the assembly.

BELLOWS.—The bellows unit assembly of the Model 199 Barton pressure unit consists of a pair of bellows, a center plate, over-range valves, a temperature compensator, a torque tube assembly, a dampener valve, and a range spring

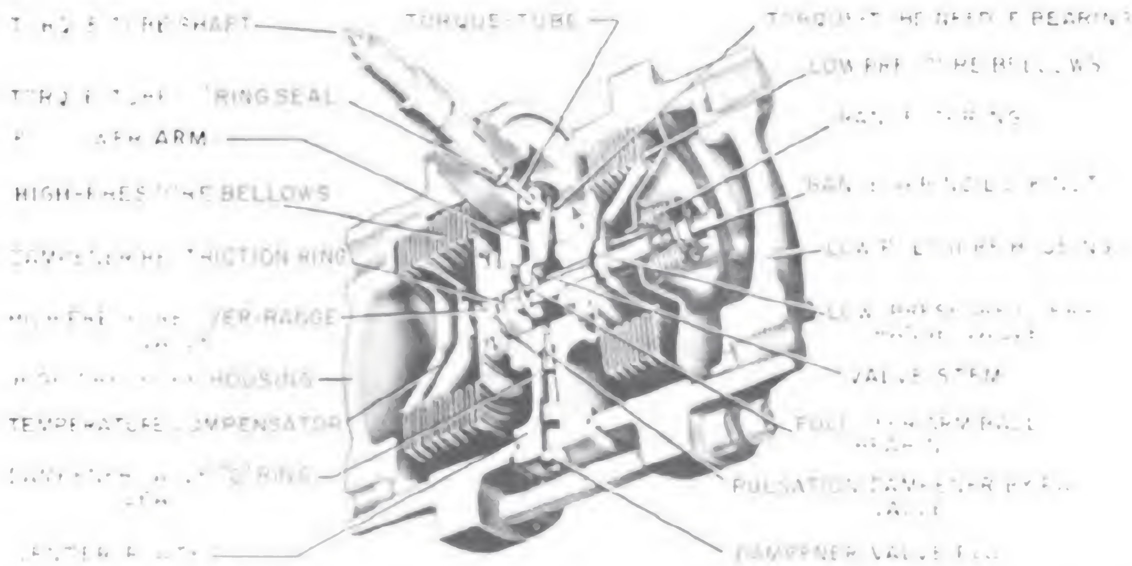

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Figure 13-5. —Differential pressure unit in the Barton Model 200 pressure gage.

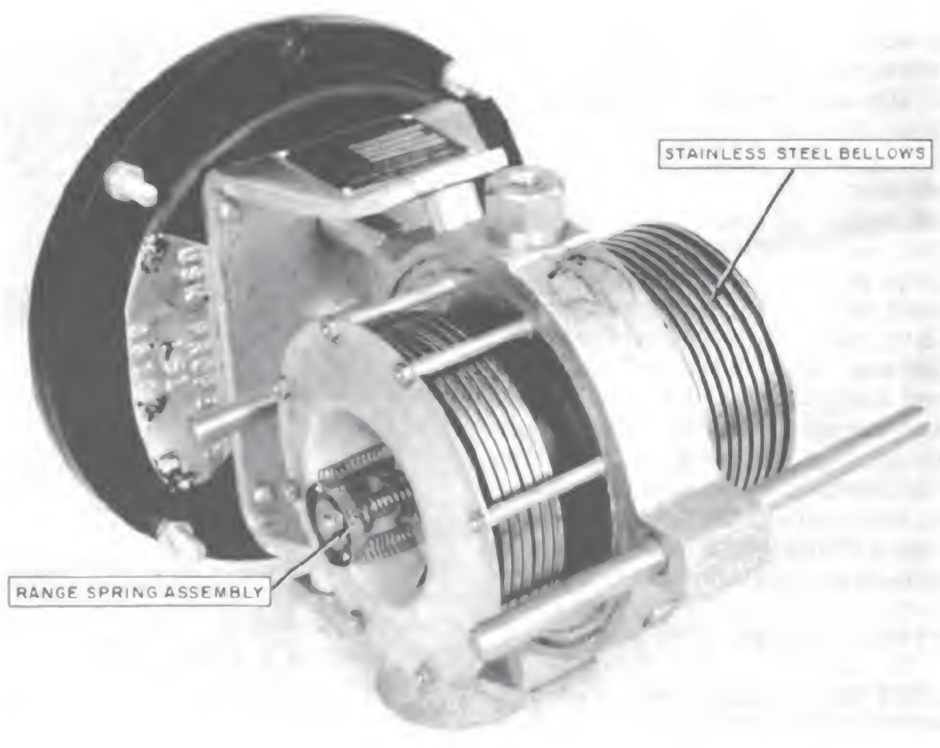

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Figure 13-6. —Bellows unit assembly in the Barton Model 200 pressure gage.

assembly. The flexible metal bellows are mounted on opposite sides of the center plate. The outer ends of the bellows are sealed; and they are connected internally by a stem passing through a passage in the center plate. The opposed over-range valves (on the connecting stem) are arranged in such manner that they seal against corresponding valve seats on the center plate. The internal volume of the bellows and the center plate is completely filled and sealed with a clean, non-corrosive, low-freezing-point liquid.

An additional free-floating bellows is attached to the high-pressure side of the bellows unit to allow for expansion and contraction of the sealed liquid, thereby providing positive temperature compensation through a wide range of ambient temperatures.

Bellows with a diameter of 3 3/4 inches are used for differential pressure ranges below 15 psi. Bellows with a diameter of 2 1/8 inches are used for measuring differential pressure above this range.

The torque assembly is part of the sealed bellows unit assembly and is employed to transmit motion of the bellows to the exterior of the unit. The torque tube provides a positive, frictionless seal and requires no lubrication or maintenance.

The differential pressure range of a bellows meter is determined by the force required to move the bellows through their normal travel. To provide for the various calibrations necessary, a range spring assembly is incorporated in the bellows unit assembly, which then accurately balances the differential pressure applied.

The bellows move in proportion to the difference in pressure applied across the bellows unit assembly. The linear action of the bellows, picked up by a drive arm, is mechanically transmitted as a rotary motion through the torque tube assembly. If the bellows are subjected to a pressure difference greater than the differential pressure range of the unit, they move through their calibrated travel plus a SMALL amount of over travel until the valve mounted on the center stem seals against its corresponding valve seat. As the valve closes, it TRAPS the sealed liquid in the bellows and (because the liquid is not compressible) the bellows are supported and cannot be ruptured, regardless of the amount of over pressure applied. The opposite valves also provide protection against over range in either direction.

All moving parts of the actuating unit except the bellows and the range springs are contained within the sealed system and are continually bathed in clean liquid. This feature makes the element practically maintenance-free.

TORQUE TUBE.—The torque tube assembly consists of a tube, a shaft, and supporting members. Study the torque tube illustrated in figure 13-7. The tube is made of thin beryllium copper tubing. The outboard end of the tube is sealed to the center plate and it passes through the center of the tube and is welded to the tube at the inboard end. The torque shaft is made of stainless steel.

Movement of the bellows is transmitted to the inboard end of the torque tube, as a rotary response, by means of a follower drive arm. Because the outer end of the torque tube is sealed to the center plate, it must twist when it is subjected to torque. The shaft (supported within the tube at its outer end and attached to the tube and follower drive arm at its inner end) rotates through the same angle as the follower drive arm.

A torque tube in the bellows unit eliminates the possibility of leakage and requires no lubrication or packing. The needle bearing which supports the inboard end of the torque tube and the ball bearing attached to the follower drive arm operate with little friction, because they are continuously bathed in the clean lubricating fluid sealed within the unit. For this reason, corrosion is eliminated, and friction cannot build up after installation. Because the torque tube is twisted through a fraction of its total workable range only, it is not subject to fatigue.

RANGE SPRINGS.—Note the position of the range springs in the pressure unit. They act with the bellows and torque tube to balance the differential pressure applied to the unit. The range spring assembly consists of a support plate, an end plate, and several individual springs. The number and spring rate of the springs used depends upon the differential pressure range desired. One end of each spring plate is rigidly attached to the center plate of the bellows unit assembly by supporting posts. The end plate is secured to a push rod located on the center line of the low-pressure bellows.

Motion of the bellows causes the springs to operate under tension. The range spring assemblies are stamped with the differential pressure range they produce and they are interchangeable for ranges between 0 and 20 inches

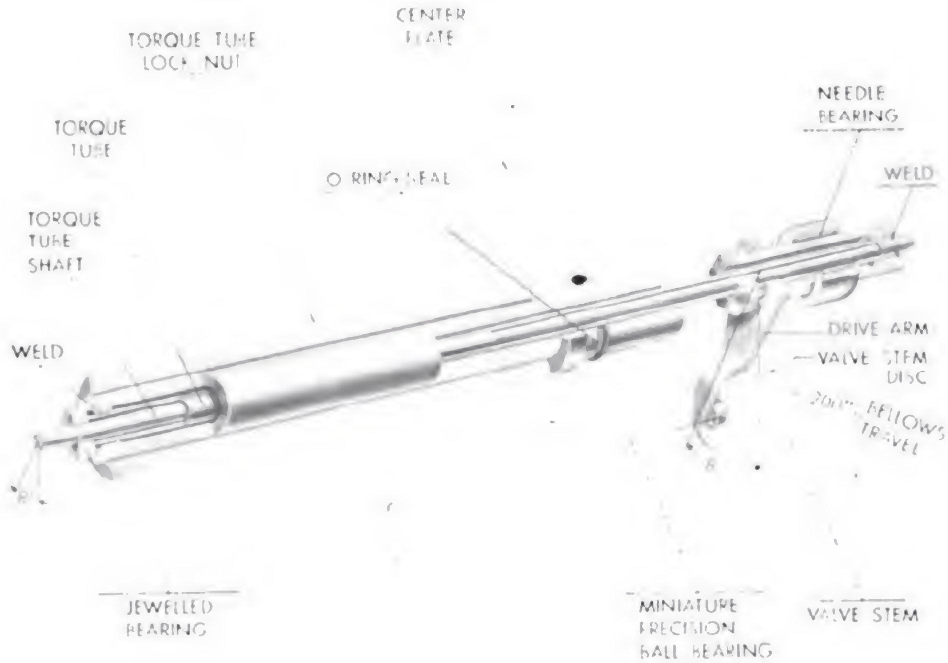

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Figure 13-7.—Torque tube assembly in the Barton Model 200 pressure gage.

w.c., and 0 and 400 inches w.c. for bellows 3 3/4 inches in diameter. Interchangeable assemblies are also available for ranges from 0-15 psi to 0-50 psi used with bellows which have a diameter of 2 1/8 inches.

TEMPERATURE COMPENSATOR.—To provide for expansion and contraction of the sealed liquid as a result of changes in ambient temperature, an extra bellows is attached to the high-pressure side of the actuating unit. This extra bellows is connected to the main bellows by a passageway through the end of the high-pressure bellows and it acts as a surge chamber to permit the sealed liquid to change volume without materially affecting the pressure inside the bellows or the physical relation between the two measuring bellows. A change of temperature in a meter actuated by a bellows is less than .4 percent per 100° F of the change of the ambient temperature.

PULSATION DAMPENER.—Note the position of the pulsation dampener by-pass valve and the dampener valve plug in illustration 13.5. Internal dampening is accomplished by restricting the flow of liquid through its normal channel (the passage in the center plate) and causing it to pass through an alternate route controlled by an adjustable needle valve. Response time of the instrument can be controlled continuously from about one second to several minutes for full-scale travel of the bellows.

DRAINING AND VENTING.—High- and low-pressure housing of the differential pressure unit are provided with top and bottom pressure connections in order to make the unit self-draining on gas installations. This feature eliminates the need for seal pots when wet gases are being measured; and if SLUGS of liquid enter the meter when a gas flow is being measured, the liquid drains from the meter automatically. When this unit is used in liquid service and installed in accordance with standard practice, it is self-venting.

GAGE REPAIR

You learned in Instrumentman 3 & 2, NavPers 10193-B, how to recharge cylinders in one type of gage comparator, and how to care for the comparator. You also learned in that text how to compute gear ratios for increasing

and decreasing revolutions per minute of tachometer tester output shaft. In this text, you have already studied the procedure for truing hairsprings in the flat and in the round, and also the procedure for colleting and studding them.

The purpose of maintenance of gages is the preservation of their useful life and continuous accurate indication. It is therefore necessary to service and repair gages periodically. Records of service—calibration, casualty analysis, repairs made, and so forth—should be available when you start to repair specific gages.

Normal repair of gages consists mostly of replacing broken crystals and damaged pointers; but all reusable parts in a gage should be salvaged for later use, if necessary. Pointers should rest about 1/16 inch to 1/8 inch above the dial, and you may have to ream out the hubs of some types in order to get them to fit properly on the spindles. This means that you need proper tools and equipment.

Air used for checking and calibrating gages must be pure. If the air used for this purpose contains oil, it will cause an explosion if the gage has been used with oxygen. It is therefore best to use bottled or filtered air on pressure gages.

Tools and Equipment

Some of the tools required for gage repair include:

1. Pointer set (including lifter).
2. Two pairs of tweezers for hairspring work.
3. Orange sticks for cleaning bearings, and pipe cleaners and brushes for general cleaning.
4. Small jeweler's anvil, a jeweler's or small machinist's bench vise, and a small hand vise.
5. Set of jeweler's screwdrivers, regular screwdrivers, regular and long-nose pliers.
6. Set of pin vises and a set of pin punches.
7. Set of small needle files and a soldering torch (electric soldering iron).
8. Hand drill and a set of drills.
9. Taper reamers.
10. Motor-driven vacuum pump for vacuum testing.
11. Gage testers and comparators.

Casualty Analysis

When you receive a gage in the shop for repair, check available records of previous service on the gage. Then inspect the gage for probable damage. Check the case, the crystal, and the pointer. You may be able to adjust the pointer from the back of the case. If this is not possible, remove the bezel, pointer and dial, and check for trouble in the operation of the gage. Use precaution to safeguard all parts. If a gage is badly damaged, discard it; when necessary, if spare parts are available, replace defective parts. Under emergency conditions, you may have to repair and reuse most parts in pressure gages that are badly damaged.

Pressure Standards

When you test or calibrate a gage, as you learned previously, you must apply pressure to the gage at the same time you apply the pressure to a standard gage of KNOWN accuracy and then compare the readings of the two gages. The test gage (standard) used should have an accuracy TEN TIMES as great as the gage undergoing a test.

Pressure standards which have such high accuracy that they may be used for checking other standards are called PRIME standards. Prime standards are produced by master deadweight testers and also by accurately calibrated, temperature-controlled mercury columns. Both of these standards may be used for testing pressure gages.

Mercury Column

A mercury column, shown in figure 13-8, works on the principle that applied pressure is balanced by a column of mercury. The height of the liquid column multiplied by the density (mass per cubic volume) is equal to the pressure applied. The column of liquid is contained in a constant-diameter glass tube whose height is read on a scale behind or adjacent to the glass tube. The mercury column is usually provided with a reservoir (well) of constant diameter. Because the reservoir is many times greater in area than the tube, the level in the well changes only slightly as the mercury goes up or down.

Graduations of the scale on the mercury column are usually corrected for the transfer of the fluid from the well into the column, because the pressure applied is balanced by the column of liquid whose height is measured from the surface in the tube to the surface in the well.

Accurate mercury columns have corrections made for altitude and latitude to compensate for

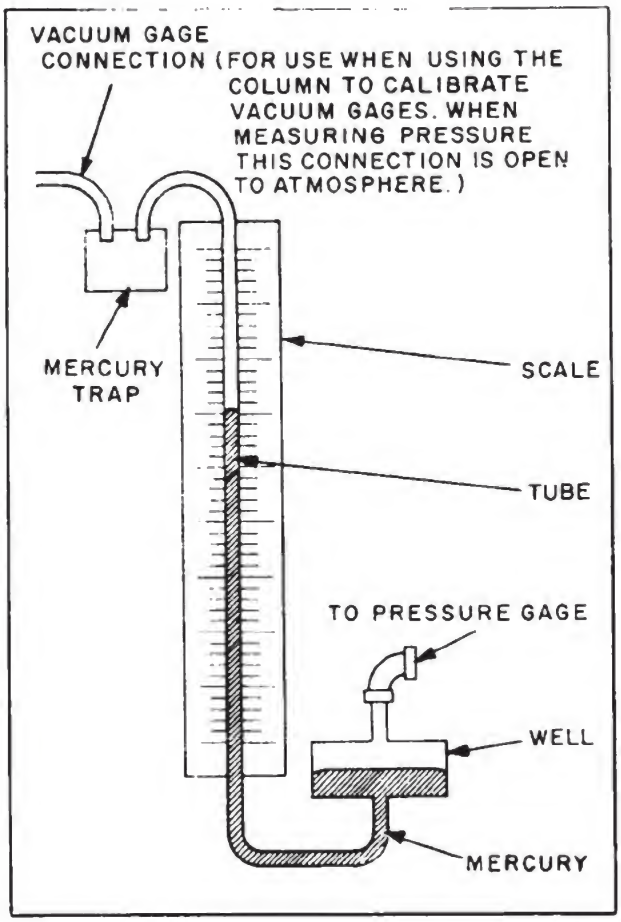

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Figure 13-8.—Mercury column.

gravitational effects caused by the earth's rotation. The maximum variation in gravity within the U.S. is .3 percent; from the highest altitude at the equator, the extreme variation of gravity is .6 percent.

Mercury columns must be kept clean, free of dirt, oil, or any other contaminating substance; and the proper level of mercury must be maintained.

The pressures stated in most standard tables, such as altitude tables, are for mercury at zero degree centigrade. A correction is applied to the scale graduations to permit operation at a nominal temperature of 25° centigrade. The readings are then in mm. or inches of mercury at zero degree centigrade. Readings taken with the mercury temperature above or below the nominal by more than a few degrees must be corrected for the actual temperature.

If mercury columns are not set up plumb, measurements with them are erroneous. These columns are used to calibrate both vacuum and pressure gages, and they are available in various heights, commonly 30 inches.

The mercury trap serves to catch overflow of mercury because of improper operation of a mercury column. CAUTION: Mercury is toxic, and it must not enter cuts or the mouth. If you spill mercury, clean it up IMMEDIATELY. If mercury touches brass, bronze, or other copper alloys, it forms an amalgam.

Deadweight Gage Tester

In its simplest form, a deadweight gage tester is a device which uses a weighted piston to obtain a definite oil pressure in a system. The piston is fitted with a platform on which weights can be placed. You studied one type of deadweight gage tester in Instrumentman 3 & 2, NavPers 10193-B; so in this text we discuss another type which you will use for testing pressure gages. Study illustration 13-9.

The Mansfield and Green gage tester shown in figure 13-9 may be used as a deadweight tester and also as a gage comparator. It is a twin-seal, piston-type, hydrostatic unit, designed specifically for testing pressure gages. The unit consists of an oil reservoir, relief valve, and a vernier valve and handle. The oil reservoir contains the quantity of oil necessary for building up the amount of pressure required for testing various gages. When closed, the relief valve permits the building up of pressure within the unit. The function of the vernier valve is to adjust built-up pressure to the desired, exact value.

As pressure applied to the oil in the chamber increases until it is equal to the force exerted by the piston, the piston rises and rides on the oil. The pressure is then constant. If you therefore know the area of the end of the piston, the weight of the piston (plus weight of platform and weights), you can calculate the pressure in pounds psi.

Because of its high accuracy as a pressure standard, a deadweight tester is used for checking most pressure ranges. Delicate test gages with an original accuracy of 1/4 of 1 percent show an increasing error with use; but an accuracy of 1/10 of 1 percent can be maintained in a deadweight tester for years.

The accuracy of deadweight gage testers used in the Navy must be (by specification) 1/10

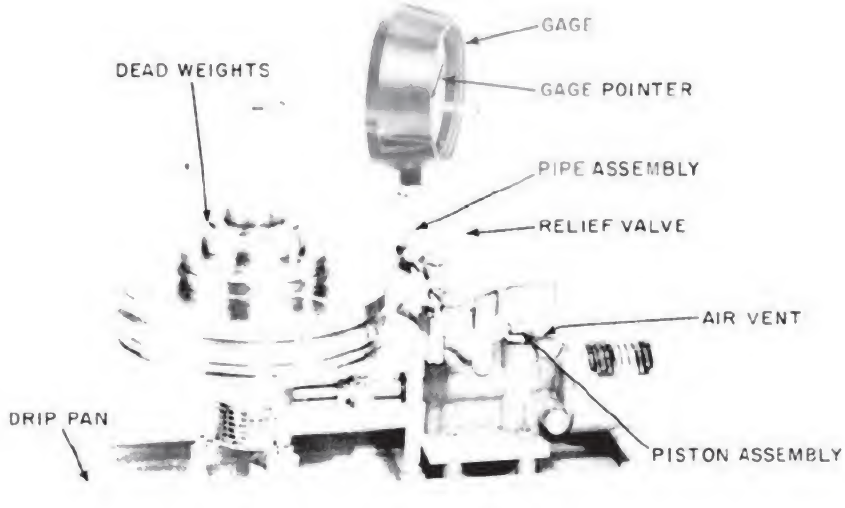

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Figure 13-9.—Mansfield and Green gage tester.

of 1 percent of the actual reading for each weight delivered with the set. Weights must also be marked in accordance with corresponding pressure equivalents, and they must be accurate within 1/20th of 1 percent. The accuracy of a deadweight tester is dependent upon five factors:

1. Accuracy of weights.
2. Tolerance of the piston.
3. Fit of the piston in the cylinder.
4. Actual versus effective piston area.
5. Stack heights and diameter of the weights.

Numbers are stamped on each dead weight to indicate the pressure produced by the weight. For example, four-inch diameter weights (serial numbers 1056-6 to 1056-8) and the five-inch diameter weights (1056-81 and subsequent numbers) are stamped 20 in one place and 100 in another place (on the upper surface). These numbers indicate that when the low-pressure piston is used the weight produces 20 pounds psi pressure; and when the high-pressure piston is used, the same weight produces 100 pounds psi pressure.

An attachment for the Mansfield and Green deadweight tester is illustrated in figure 13-10. It consists of a cylinder which fits on the test unit, one low-pressure piston, and one high- and low-pressure piston. The low-pressure piston is used for dead weights with serial numbers 1056-6 through 1056-80, and the high- and low-pressure piston is used for weights with serial numbers 1-56-81 and subsequent numbers.

Now study illustration 13-11, which shows the Mansfield and Green deadweight tester converted into a portable gage comparator. Observe the positions of the two gages on the comparator. This testing unit also has a high-pressure hose assembly for use when you transport the unit to a certain position to test a gage. See figure 13-12.

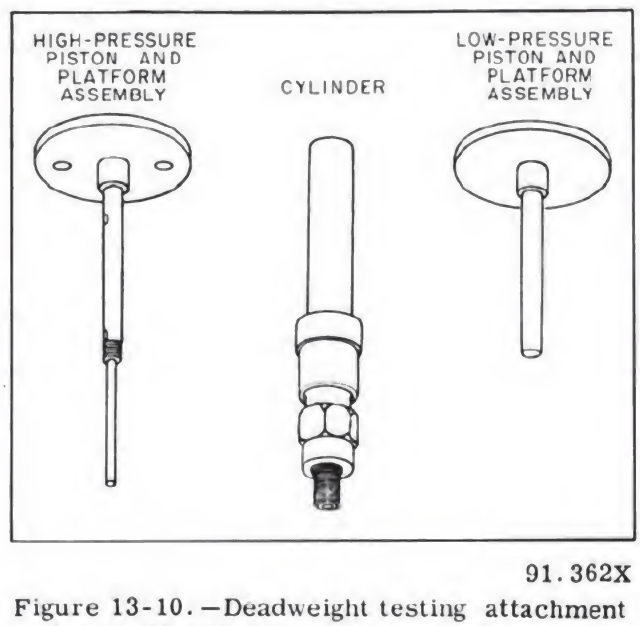

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Figure 13-10.—Deadweight testing attachment for the Mansfield and Green gage tester.

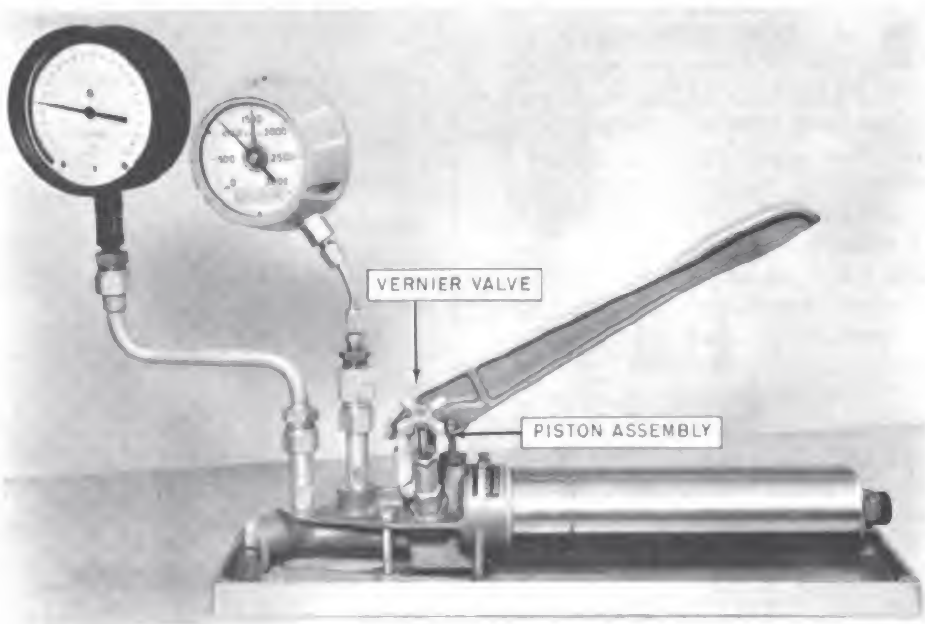

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Figure 13-11.—Mansfield and Green gage tester converted to a gage comparator.

Before you start to use a Mansfield and Green deadweight gage tester, remove the fill plug at the end of the reservoir and check the amount of oil in the hand pump reservoir. If oil is required, use only the type recommended by Navy specifications. Attach the gage in order to minimize the effect of oil head pressure. For permanent testing, bolt the drip pan on the bench.

You already learned how to operate a deadweight gage tester, but definite specific instructions relative to the operation of the valves on the Mansfield and Green tester are in order, as follows:

1. Close the relief valve to develop desired pressure by operating the hand pump. Continue the pumping until the piston floats about 1/2 inch above the piston rest position.

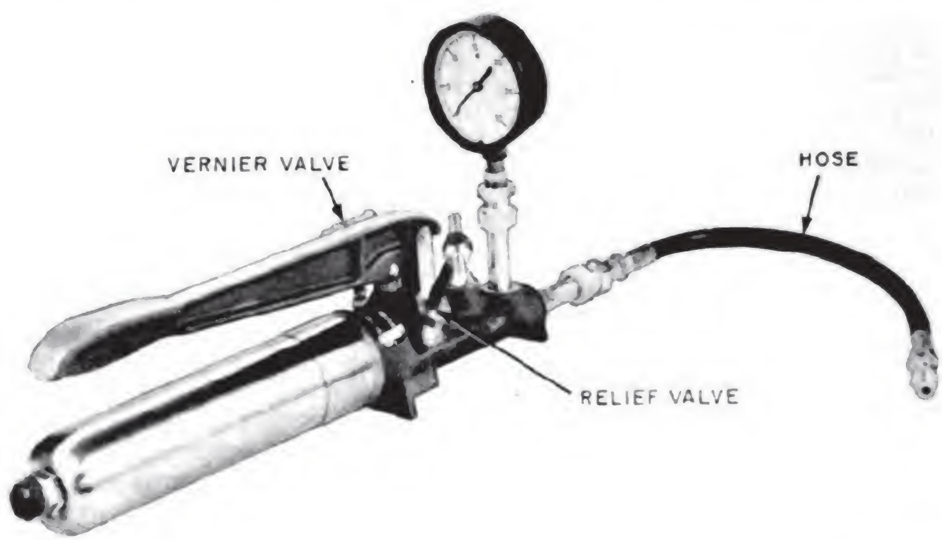

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Figure 13-12.—Hose attached to a Mansfield Green gage tester for testing gages on location.

2. Use the vernier valve to obtain EXACT pressure. Action of the vernier piston complements pump action.

3. Before you remove a weight from the platform, unscrew the vernier adjustment to lower the piston. NOTE: You may need to open the relief valve in order to avoid raising the piston too high. Do NOT remove the gage until the pressure returns to zero.

When you test a gage ON LOCATION with a gage tester (comparator), compare the pressure indicated on the gage being tested with the pressure shown on the test gage. NOTE: You can make this test ONLY if there is a cut-off valve in the line. See figure 13-13. With a tee fitting, you can simultaneously check the pressure indicated on both gages.

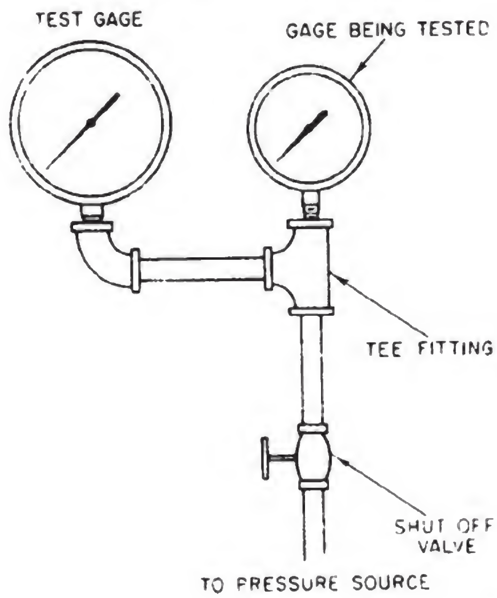

Figure 13-13. —Tee fitting in pipe line for testing a gage on location.

As your standard for testing gages in an instrument shop, use a deadweight tester or a mercury (or water) column. It is generally best to use mercury columns and low-pressure master gages for testing in the low ranges of pressure, and deadweight testers and extended-range master gages for testing gages in the middle- and high-pressure ranges.

When you use a Mansfield and Green tester, keep the manufacturer's technical manual for it available for ready reference.

Grove Comparator

The procedure for operating a Grove comparator was explained in Instrumentman 3 & 2, NavPers 10193-B, along with the method to use for recharging the cylinders. This section is therefore limited to an explanation of the operating principle of a loader valve in a Grove comparator, which you must understand before you can qualify for advancement in rating to a Chief Instrumentman. As you study the discussion, refer to figure 13-14, which shows the disassembled parts of a loader valve (just removed from a comparator) and a schematic view of the valve.

A loader valve in a Grove comparator is an accurate pressure reducing valve with built-in automatic relief in the center core within the spring. The core is the relief actuator. Because of its large diaphragm-to-valve area ratio, it provides pound-by-pound controlled accuracy of delivery pressure.

The principle of operation of a Grove loader valve is as follows: As you operate the handwheel, you increase tension on the spring and force the inlet valve in the base from its seat, thereby admitting pressure to the diaphragm chamber and the outlet line. When the pressure on the diaphragm produces a force equal to the adjusted spring tension, the diaphragm rises to close the inlet valve. If the spring tension is reduced, pressure on the diaphragm is greater than the spring force; and the diaphragm assembly, including the relief valve seat, rises to allow the relief actuator in the adjusting stem to open the relief valve.

When spring tension on the diaphragm is fixed, any increase of pressure on the diaphragm causes it to lift as the pressure overcomes spring tension and opens the relief valve (above inlet valve in the adjusting stem) to automatically emit enough gas to maintain the adjusted pressure at the set point. If the diaphragm chamber pressure decreases, tension on the spring moves the diaphragm assembly and causes the inlet valve to open and admit to the chamber the amount of gas necessary to maintain the pressure setting.

A grove loader valve also has an adjustment screw under the nut on the handwheel for making adjustments for accuracy or dead range of the tester. This adjustment is called the SENSITIVITY ADJUSTMENT.

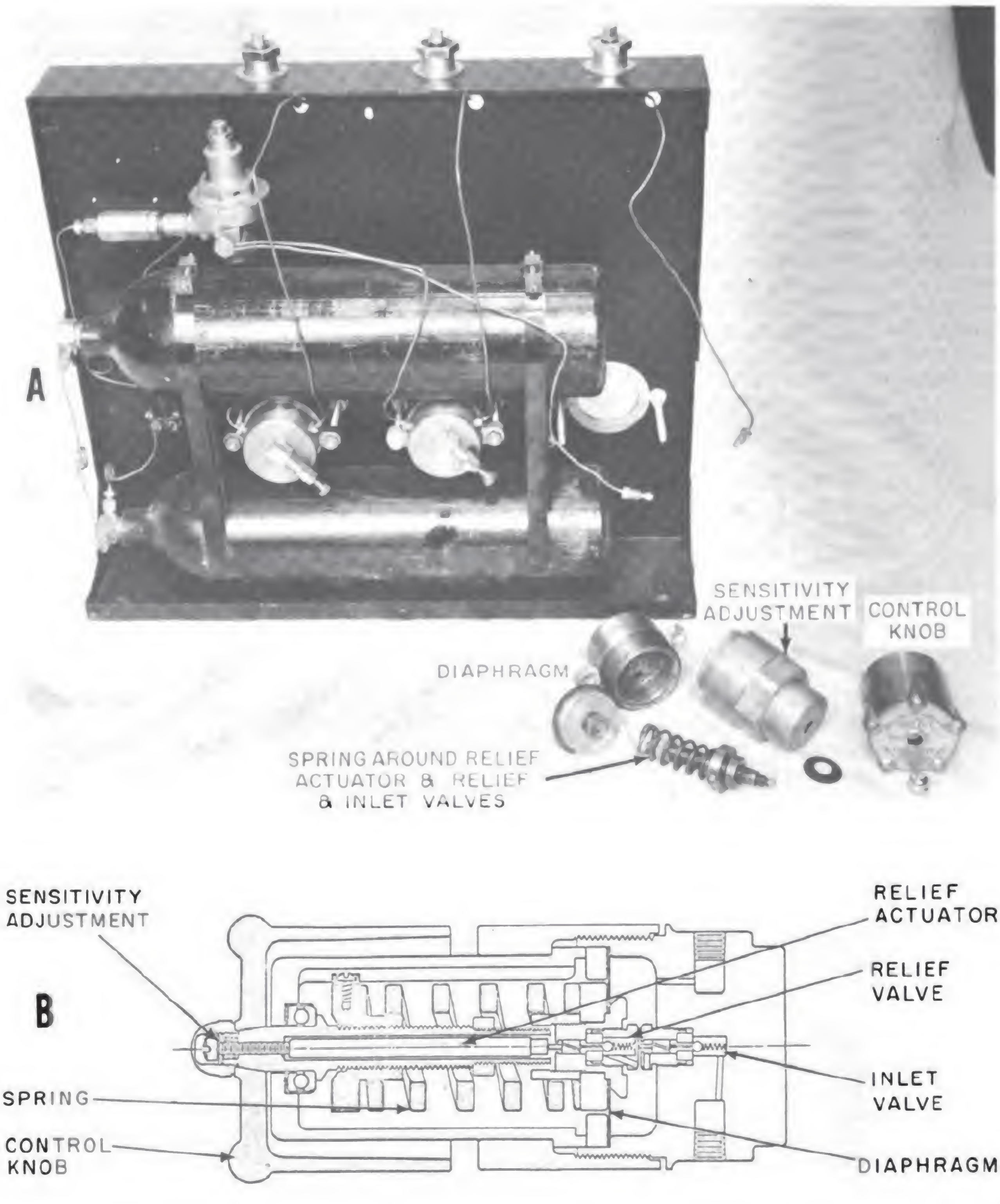

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Figure 13-14.—Rear view of a portable Grove gage comparator (one loader valve removed and disassembled).

Aneroid Barometer Tester

A barometer is an instrument used for measuring atmospheric pressure. There are two types of barometers, mercurial and aneroid. The mercurial barometer consists of a glass tube, the top of which is sealed and contains a vacuum. The bottom of the tube is open and submerged in a cistern of mercury. The mercury column in the tube generally stands at about 30 inches, with a space of approximately 2 inches of vacuum and a little mercury vapor above it. As the pressure of the atmosphere rises, the mercury column rises in the tube; when atmospheric pressure falls, the height of the mercury column in the tube also falls.

Your ship's navigator sometimes uses barometers to predict weather. If the column of mercury rises, the weather will probably be fair and cooler; if the mercury falls, the weather will most likely be inclement. When the mercury remains at the same position in the barometer, the weather generally remains constant. Fire Controlmen also use barometers to correct range settings for atmospheric pressure, which affects the travel of projectiles.

An aneroid barometer has a diaphragm assembly—a sealed metal chamber (partial or complete vacuum) with flexible walls—as its actuating element. Study figure 13-15.

One wall of the chamber is secured to the frame of the instrument. When atmospheric

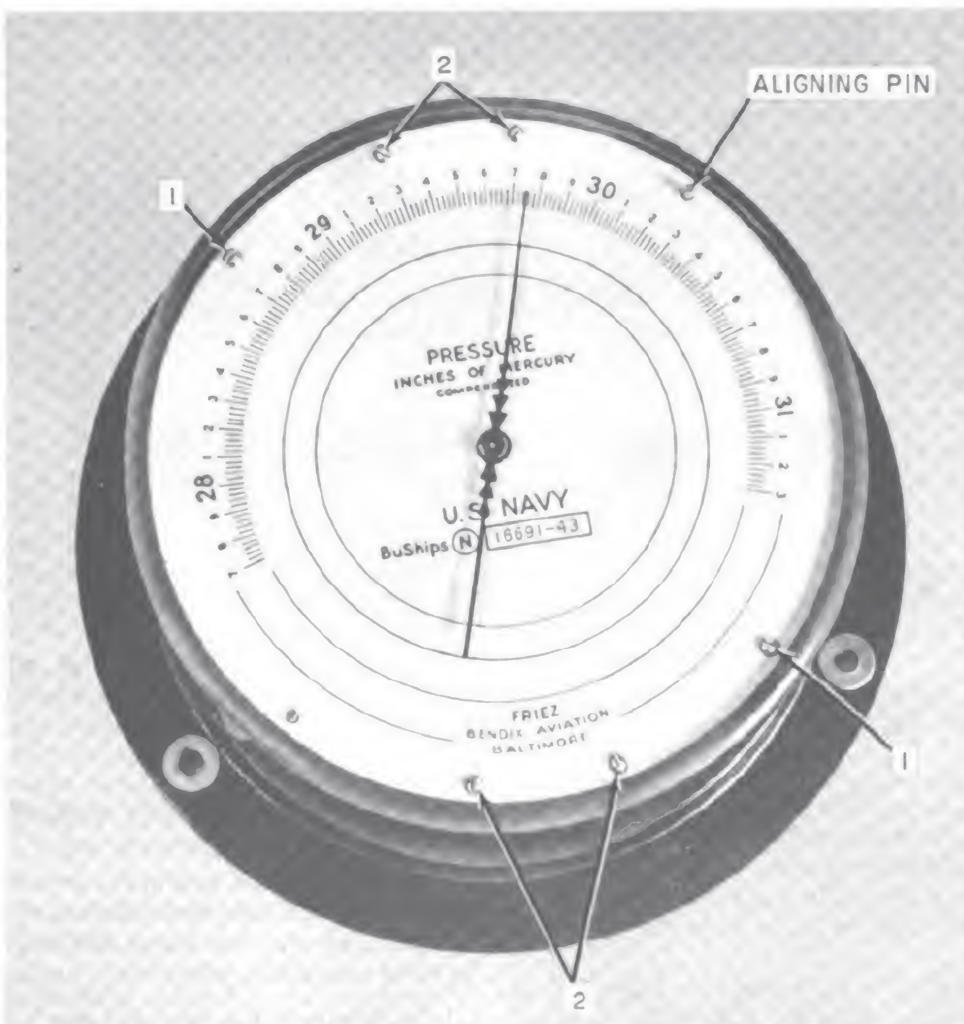

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Figure 13-15.—Aneroid barometer with bezel removed.

pressure rises, it compresses the chamber; when pressure of the atmosphere falls, the chamber expands. The free wall of the chamber is connected by a system of levers (part A, fig. 13-16) to the indicator hand pivot, and any change in the pressure of the atmosphere moves the diaphragm wall. Through a system of levers, this wall then turns the indicator hand. If the barometer is properly calibrated, it indicates accurate atmospheric pressure on the dial.

The following procedure is recommended for overhauling one type of barometer (Friez) used by the Navy:

1. Remove the bezel ring by screwing it counterclockwise. NOTE: Carefully inspect parts as you remove them.
2. Lift the plastic crystal off. If the crystal is scratched, buff it with a fine rouge paste.
3. Inspect the set hand. Clean and straighten this hand, as necessary, and give it a coat of clear lacquer.
4. Test the movement of the set hand knob. If the knob does not stay where you put it, use a punch to spread the rivet which secures it.

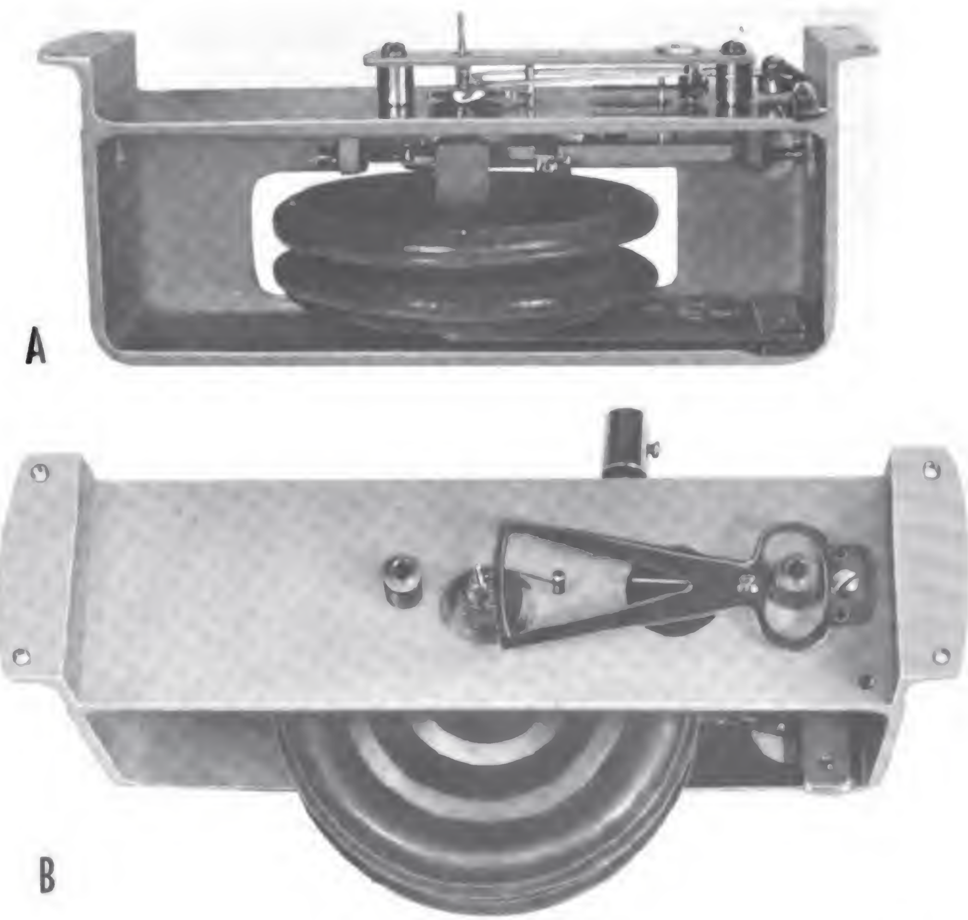

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Figure 13-16.—Movement assembly of an aneroid barometer.

5. Remove the spacer ring which supports the crystal.
6. With a hand remover, gently lift the indicator hand off its pivot and inspect it. It must be straight and the black enamel on it must be in good condition; otherwise, replace it.
7. Remove the two screws which hold the dial in the case. Then hold the case in one hand and put your other hand over the dial to turn the instrument over and lift the case off.

Rest the instrument on a work bench, dial up, and remove the dial.

8. Hold the movement with the indicator hand pivot up and press down gently on top of the diaphragm. Then observe the action of the levers in the linkage. Note the horizontal pin which passes under the horizontal pin at the top of the diaphragm. The sector spring keeps these two pins in contact to transmit the movement of the diaphragm through the linkage to the indicator hand.

9. With a pair of tweezers, remove the sector spring from the sector. Then remove the spring bracket from the spring and inspect the spring. If it is out of shape or weak, replace it.

10. Remove the screw at each end of the bridge and lift it off. CAUTION: Do NOT pull the indicator hand pivot out of its lower bearing.

11. Lift off the two bridge posts and remove the sector assembly from its bearing.

12. The outer end of the hairspring passes through a hole in the hairspring post, where it is secured by a small pin. Remove the pin, free the hairspring, and lift out the indicator hand and pinion assembly.

13. With a small socket wrench, loosen the two lock nuts on the lever pivot screws; then loosen the pivot screws and remove the lever. Inspect the lever for straightness and the condition of the jewel in each end. If a jewel is chipped or cracked, replace it.

14. Remove the pivot screws and inspect their condition with a magnifying glass. Repoint or replace them, as necessary.

15. Turn the frame upside down and remove the screw from the end of the frame. Then remove the indicator hand adjusting screw (near center of frame) and lift out the diaphragm assembly.

16. Remove the screws which secure the diaphragm assembly to its clamp plate.

17. Carefully inspect all parts. With a loupe, examine the two jewels in the top of the frame and also the two jewels in the bridge. If the jewels are damaged, press them out and insert new jewels. If the diaphragm leaks, install a new assembly.

Accuracy of operation of an aneroid bar[illegible] ter is obtained when:

1. The diaphragm chamber is comp[illegible] sealed. If the chamber leaks, it will NOT respond to changes in the pressure of the atmosphere.

2. It is properly calibrated.

3. There is freedom of movement of all levers in the unit. If there is binding in the levers connected with the indicator hand, the hand cannot respond accurately to the movement of the diaphragm.

4. There is proper functioning of the complete linkage system. There must be neither BINDING nor LOST MOTION in the linkage. All parts must fit properly and function smoothly in order for the hand to give accurate indication on the dial.

Before you can qualify for advancement in rating to a Chief Instrumentman you must know how to disassemble, clean, lubricate, reassemble, and calibrate an aneroid barometer. Maintenance procedures for this type of barometer are therefore discussed in the following paragraphs.

Check the frame of the barometer. If necessary, apply a coat of paint. Then inspect the condition of the sector on all pins. Clean rust or corrosion from parts by buffing, or by dipping them in a 30 percent solution of hydrochloric acid. CAUTION: Remove the parts from the acid as soon as the rust or corrosion is dissolved and rinse them in water. Then dry them with a clean cloth.

If the hairspring is bent or shows signs of rust or corrosion, replace it. If the dial cannot be read easily, remove the lacquer and letters with paint remover and wash the dial in benzene. Then dry it and give it an acid bath; rinse and dry it again. Refill the letters and graduations with black enamel. When the enamel is dry, give the face of the dial a coat of clear lacquer.

Wash metal parts in benzene; then dry them and apply a thin film of oil to unpainted parts. NOTE: Use a lint-free cloth to apply the oil. Apply oil to all six jewels, but keep it off the hairspring.

Reassembly of the barometer is the reverse of disassembly. Make proper adjustments as you reassemble parts.

After you adjust the pivot screw, retighten the lock nuts. When you have the movement in the case, line up the indicator hand adjusting [illegible] hole in the back of the case. [illegible] eric pressure on a mer- [illegible] lace the indicator [illegible] Replace next the [illegible], and make the final set- [illegible] ator hand with the adjusting screw (through hole in back of case).

You can calibrate an aneroid barometer by using a tester like the one illustrated in figure

13-17. This tester consists of an air bell connected to a vacuum pump, which is also attached to a mercury column (illustrated). When you put an aneroid barometer in the air bell and evacuate the air, the reading on the mercury column and the barometer should be identical.

If you must adjust the mechanism of a barometer, hold it in the position shown in part B of figure 13-16 and change the position of the lever by partially releasing one of its pivot screws and by tightening the other screw. If the movement is TOO SLOW, move the lever to the right; if the movement is TOO FAST, move the lever to the left. Then replace the movement in the case and repeat the test. Make additional adjustments, as necessary.

91.369
Figure 13-17.—Aneroid barometer tester.

TACHOMETERS

You studied the mechanisms of tachometers in Instrumentman 3 & 2, NavPers 10193-B, and also learned how to compute gear ratios for increasing and decreasing revolutions per minute of a tachometer tester output shaft. In this text, you already learned how to repair watches and clocks; and the knowledge you gained thereby will enable you to repair and adjust the timing mechanisms of tachometers.

The following discussion is therefore limited to a discussion of the operation and maintenance of a tachometer test stand.

TACHOMETER TEST STAND

Illustration 13-18 shows one type of tachometer test stand used by the Navy. It is an Ideal-Aerosmith, used as a representative type for discussion in this chapter.

The Ideal-Aerosmith tachometer test stand is a self-contained, bench-type unit, whose main driving components are a 1/2 horsepower, 60 cycle, 115 volt motor which uses alternating current (AC), and a variable-speed hydraulic transmission. Study the position and nomenclature of these components in figure 13-19.

The hydraulic transmission is coupled to the tachometer output shaft by a timing belt and pulleys. The driving mechanism is shock-mounted, and the entire assembly is mounted in a standard 19-inch cabinet. The unit has a standard generator mounting pad on the front of the case and a similar pad on the inside of the case for mounting a master generator, if desired.

The front panel of the test stand has mounts for three tachometers. The hand wheel operates the speed-control screw, and speed control is monitored by a stroboscope tube and disk. Note the belt to this disk (fig. 13-19), and also the speed-control screw and the speed-control arm. A special switch for the stroboscope tube enables an operator to turn it ON or OFF at will.

Accessories provided with an Ideal-Aerosmith tachometer test stand include:

1. Flexible shaft, 24-inch, Aerosmith standard, 7/8 inch to 18 thread.
2. Flexible shaft, 24-inch, waltham type.
3. Adapter, dual, parallel, 1 to 1 ratio, 7/8 inch to 18 thread.

91.370
Figure 13-18.—Tachometer test stand.

4. Adapter, dual tee, 1 to 1 ratio, 7/8 inch to 18 thread.

5. Step-up pad-to-pad adapter, 1 to 2 ratio.

This tachometer tester has a speed range (direct drive) from 0 to 5,000 rpm, and its accuracy is from 1/2 percent to 1 percent. The drive shaft is mounted on sealed ball bearings and it has a standard pad-type mount at each end. Adapters (provided) convert these pad drives to 7/8 inch to 18 threaded-type aircraft standards.

A permanently installed master tachometer helps to prevent misinterpretation of the stroboscope. It is driven by the inside drive.

OPERATING A TACHOMETER TESTER

To operate an Ideal-Aerosmith tachometer test stand, proceed as follows:

1. Attach a flexible shaft to the rear drive and bring it out through one of the mount holes on the front panel and connect it to the instrument you desire to test. Then mount the instrument in a mounting rack and secure it with the spring-loaded studs.

2. Turn on the separate switch for the stroboscope and allow from 10 to 15 seconds for it to warm up. CAUTION: A stroboscope tube has limited life, so use it ONLY when you are actually synchronizing the speed of tachometers. The stroboscope synchronizes with and STOPS the OUTER band of spots at every 100 rpm indicated (50 rpm at the drive). The second band of spots synchronizes at 200 rpm indicated and at each multiple of 200. The third band of spots synchronizes at 400 rpm indicated and at each multiple of 400. The inside band synchronizes at 800 rpm and at each multiple of 800.

A combination of these four bands on the stroboscope simplifies the interpretation of the correct speed of a tachometer undergoing a test. For example, if the drive is turning 800 rpm (indicated speed of 1600), all four bands stop; because 1600 is a multiple of each figure—100, 200, 400, and 800, as just explained.

The bands on the stroboscope which stop at each increase in indicated speed of 200 rpm (outer band stopped for each increase of 100 rpm) are as follows:

INDICATED SPEED	BANDS SYNCHRONIZED		
	Second	Third	Inside
200	x		
400	x	x	
600	x		
800	x	x	x
1,000	x		
1,200	x	x	
1,400	x		
1,600	x	x	x
1,800	x		
2,000	x	x	
2,200	x		
2,400	x	x	x
2,600	x		
2,800	x	x	
3,000	x		
3,200	x	x	x
3,400	x		
3,600	x	x	
3,800	x		
4,000	x		x
4,200	x		
4,400	x		

(Higher ranges are listed in the manufacturer's technical manual for the tester.)

3. Turn on the switch for the MASTER tachometer and also the switch for the tachometer

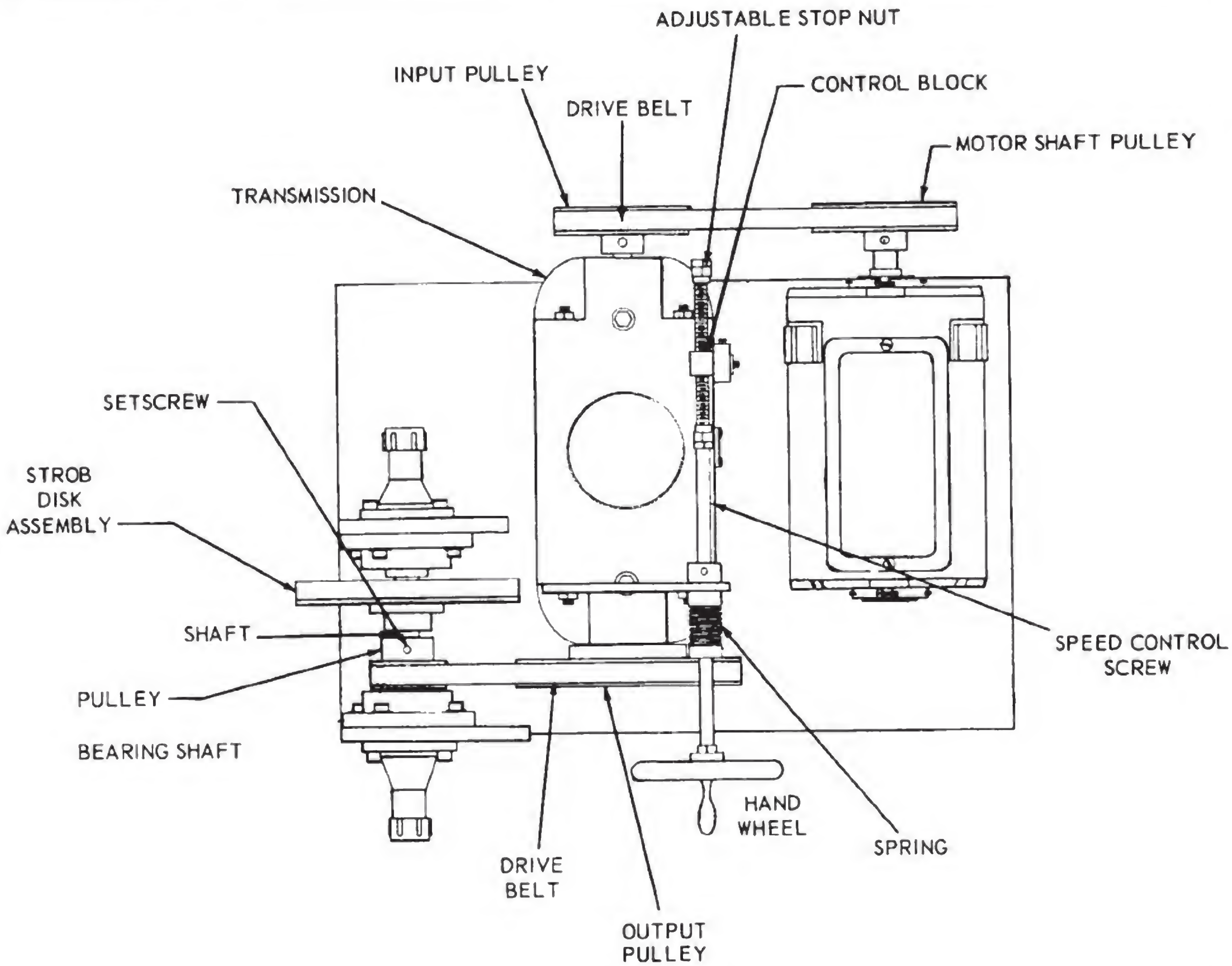

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Figure 13-19.—Mechanisms in a tachometer test stand.

being tested and compare the speed of the tachometers.

4. Turn the handwheel of the variable-speed hydraulic transmission to increase the speed of the tachometer (gradually) and observe their rates.

5. Synchronize the speed of the two tachometers with the stroboscope disk. If the speed of the tachometer under test is not identical with that of the master tachometer, adjustments are necessary.

6. Turn the handwheel to reduce the speed of the hydraulic transmission and then cut off the motor. When the speed is reduced, the drive picks up inertia of the stroboscope disk.

7. Cut off all switches.

MAINTENANCE OF A TACHOMETER TEST STAND

A tachometer test stand such as the Ideal-Aerosmith requires a certain amount of routine and periodic maintenance. Occasionally, it may require a major overhaul. Some of the maintenance required for this test stand includes:

1. Draining the transmission. Remove the cap from the pipe extension at the back of the case and tip the entire tester toward the back (90°) to allow the oil to run out of the drain pipe. Cover the belts to keep oil off while you are draining the transmission. After the oil runs out, return the tester to its normal position and replace the cap on the drain pipe.

2. Filling the transmission. Fill the transmission with approved oil (specified in the manufacturer's technical manual) to the bottom of the filler cup screen. CAUTION: Do NOT remove the screen from the cup, and remove the filler cup only when you must check the oil level or fill the unit. Check the oil level PERIODICALLY; drain and refill the transmission with NEW oil every 1,000 hours, or at the end of 6 months (whichever comes first).

3. Repacking the motor. The motor has sealed, grease-packed bearings which require repacking at the end of each year's operation.

4. Lubricating the speed adjusting screw. Lubricate this screw every three months.

5. Oiling the shaft bearings. Oil all shaft bearings periodically.

6. Replacing rectifier and stroboscope tubes. Replace these tubes whenever necessary.

7. Keeping all parts of the test stand clean. Use a clean cloth moistened with cleaning solution to wipe the inside and outside of the cabinet, the handwheel, bezel of the master tachometer, stroboscope disk, and other parts.

8. Keeping nuts and screws tight. Inspect nuts and screws periodically for tightness.

Keep the manufacturer's technical manual for this test stand available for ready reference. If you are in doubt about any procedure, ALWAYS refer to the manual.

CHAPTER 14

CALCULATORS

Before you can qualify for advancement in rating to an Instrumentman 1, you must be able to "disassemble, clean, reassemble, and make minor adjustments to calculators." In order for you to qualify for advancement to a Chief Instrumentman, you must also know how to "analyze and remedy casualties to calculators."

GENERAL DESCRIPTION

Because of the nature of the work which a calculator must perform (multiplying, dividing, subtracting), it is a very intricate machine. Many precision-made parts and mechanisms are required for the accomplishment of division or subtraction, for example. When the operator of a calculator depresses bars or keys on the keyboard (with the motor running), he sets in motion specific links, levers, bellcranks, cams, pawls, segments—whatever combination of all these parts is required, including gears and other parts, for accomplishing a specific function.

There are several good makes of calculators, including Friden, Monroe, Burroughs, and Remington; and the Navy purchases different makes and models of calculators. These machines, while different in some respects, have many similar mechanisms and parts, because the operations they must perform are the same.

Before you can remedy casualties to and adjust such a complex machine as a calculator, you must understand the function and operation of its parts and mechanisms. You must know this, in fact, before you can analyze casualties. The only way you can find out the purpose and principle of operation of a part, or mechanism, in the machine is to study carefully how the part functions individually and/or collectively in order to perform the function for which it was designed.

Discussion of the operation of all parts and mechanisms in a calculator, in sufficient detail for you to be able to understand it, requires considerable space. For this reason, only one make of calculator can be discussed in detail, as a representative type, in this chapter. If you understand the operation of parts and mechanisms in this machine, however, with the aid of the manufacturer's technical manual for a particular model, you will be able to repair and adjust other similar machines.

MODEL DM99 REMINGTON CALCULATOR

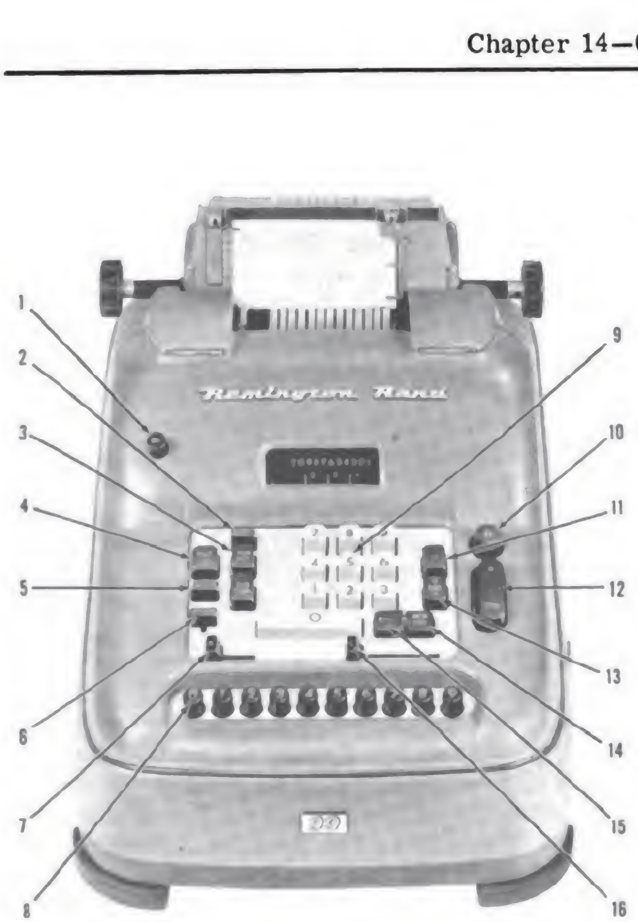
A Model DM99 Remington calculator is illustrated in figure 14-1. This machine is one of the newest and best calculators made; and the technical manual which explains the operation of parts and mechanisms also contains excellent instructions for disassembling, reassembling, inspecting, and adjusting.

Some important features of the Model DM99 calculator are:

1. Automatic Multiplication.—If you enter a multiplicand on the keyboard of a Model DM99 Remington calculator and then depress the space key once for each digit in the multiplier (less one), you can multiply automatically by depressing the multiplication keys which represent the value of each digit in the multiplier (in order of reading). The answer is printed automatically and the machine clears itself in readiness for the next operation.

If the operator desires to clear the machine before a problem is completed, he can clear it by pulling the release key forward before he depresses the last multiplier digit.

2. Short-cut Multiplication.—Short-cut multiplication is accomplished on the Model DM99 calculator when multiply keys 6 through 9 are used. NOTE: Depression of other keys is not required for short-cut multiplication.



1. Division key
2. Total control key
3. Non-add key
4. Mult. total key
5. Release key
6. Sub-total key
7. Back space key
8. Multiplication keys
9. Regular 10 key keyboard for speed
10. Decimal key
11. Subtract key
12. + and total motor bar
13. x ext. ÷ key
14. Memory key
15. Space key
16. Correction key

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Figure 14-1.—Remington Model DM99 calculator.

3. Accumulative Multiplication.—Accumulative multiplication is achieved on the Model DM99 calculator through use of the TOTAL CONTROL lever. If you position the total control lever to the left, the machine cannot automatically total after each multiplication operation. Before you multiply the last digit of a series of operations, move the total control lever to the right to get an automatic grand total.

4. Mult-total Key.—The mult-total key simplifies multiplication by allowing the operator to use space and memory keys to set spaces to the right of the multiplicand. A mechanism for eliminating zero print to the right of the product on total operations is also included with this feature.

5. Simpla-type (Printing Control).—The printing control feature on the Model DM99 machine permits the printing of essential factors and results ONLY on the tape. During multiplication, for example, the multiplicand is printed ONLY once—there is NO repetition of printing after each backspacing. The multiplier is printed along with the product. During division, the divisor is printed ONLY once.

MECHANISMS AND PARTS

All parts and mechanisms in a Model DM99 Remington calculator are discussed in considerable detail in the following pages, by necessity; for partial discussion of a particular mechanism would be confusing, and you would not understand its operation.

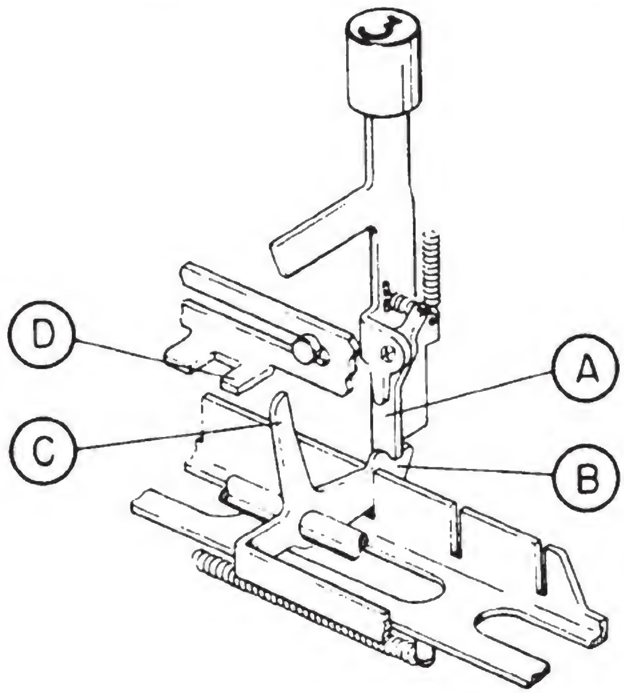
Multiply Keystem Yielding Pawl

When a multiply key is depressed, the yielding pawl (A, fig. 14-2) riveted to the keystem contacts the multiply keystem operating bellcrank extension (B) to actuate the bellcrank assembly downward and position extension (C) in the path of the keystem bellcrank operating slide extension (D).

When the keystem bellcrank operating slide extension (D) contacts extension (C), it moves the extension (C) to the right and releases the bellcrank extension to allow the extension to move up and be pulled by spring tension to the left. At the same time, extension (C) moves forward and unlatches from the keystem bellcrank operating slide extension. Because the keystem does not restore until the next stroke, the pawl yields to the left to remove pressure from the keystem and permit it to restore when it is unlatched.

Multiply Key Mechanism

The multiply key mechanism is illustrated in figures 14-3, 14-4, and 14-5. Parts of the mechanism are identified in the illustrations by numbers and letters. Note that numbers 1 through 17 and letters A through Q are used



91.373X

Figure 14-2.—Multiply keystem yielding pawl.

in figure 14-3; numbers 18 through 30 and letters R through Z are used in figure 14-4; and numbers 31 through 39 are used in figures 14-5. Note also that some parts are referenced in more than one figure, but they are always identified by the same number or letter. Refer to the applicable illustration when you study the discussion of a particular part or mechanism.

As a multiply key (3) is depressed, yielding pawl (P) (riveted to the keystem) depresses the rear extension (Q) of the keystem operating bellcrank (14), which rotates to position its upper front extension (L) in the path of extension (M) of the keystem bellcrank operating slide (15). The keystem bellcrank extension (Q) also rotates the keystem bellcrank comb (13) which, in turn, operates the motor drive control bellcrank (12) and the multiply non-print bellcrank latch actuator (21) (fig. 14-4).

When the multiply non-print bellcrank latch actuator (21) rotates, it raises link (20) to position step (R) of the multiply non-print bellcrank latch (19) out of the path of roller (S) on the multiply non-print bellcrank. Roller (U) then contacts extension (V) of the multiply non-print bellcrank restoring arm pawl (24) to release step (W) from roller (T) on the multiply non-print bellcrank restoring arm (23). The multiply mechanism operating slide (28) moves rearward through spring (29) to release stud (Z) from the operating slide retaining pawl link bellcrank (39, fig. 14-5), and to allow bellcrank (39) to rotate and position the operating slide retaining pawl link (38) to the left through spring (37). Link (38) then releases the operating slide retaining pawl (35) to permit it to engage the keystem bellcrank operating slide (15), through spring (36).

When the motor drive control bellcrank (12, fig. 14-3) rotates, the keystem lock pawl retaining link (9) moves down to position pawl (B) in the path of roller (J) on the keystem lock release arm. At the same time, the upper extension of bellcrank (12) moves the automatic total and motor drive control connector link (10) to the rear, thereby causing roller (G) on it to release control arm (C) of the keystem lock release arm (8) from roller (D) on the gear arm (R) of the universal drive shaft (7). This action allows the keystem lock bail (16) and the keystem lock release arm to move rearward under spring tension and carry with them pawl (B) and the control arm latch assembly (5). The last movement unlatches the motor drive control arm (3) and operates the motor (under tension of spring 4). As the keystem lock bail (16) moves to the rear, it latches over extension (N) of the multiply key.

As the machine operates, the universal drive shaft (7) actuates the operating slide pawl (34, fig. 14-5) through the operating slide feed pawl arm (32) and the operating slide feed arm pivot shaft (33), to move the keystem ballcrack operating slide (15) one space to the right of each main shaft operation, where it is latched by the operating slide retaining pawl (35).

An extension (Y, fig. 14-4) of the multiply non-print bellcrank restoring arm pawl (24) contacts stud (X) of the non-print bellcrank latch actuator (21) to prevent step (W) from relatching roller (T). Arm (F) (fig. 14-3, insert) on the universal drive shaft (7) moves downward to permit the multiply motor drive bellcrank latch (17) to latch over extension (A) on the control connector link (10), through spring (1).

Extension (M) (figs. 14-3 and 14-5) on multiply keys 2 through 9 contacts extension (L) on the stroke next to the last forward stroke and moves the keystem operating bellcrank

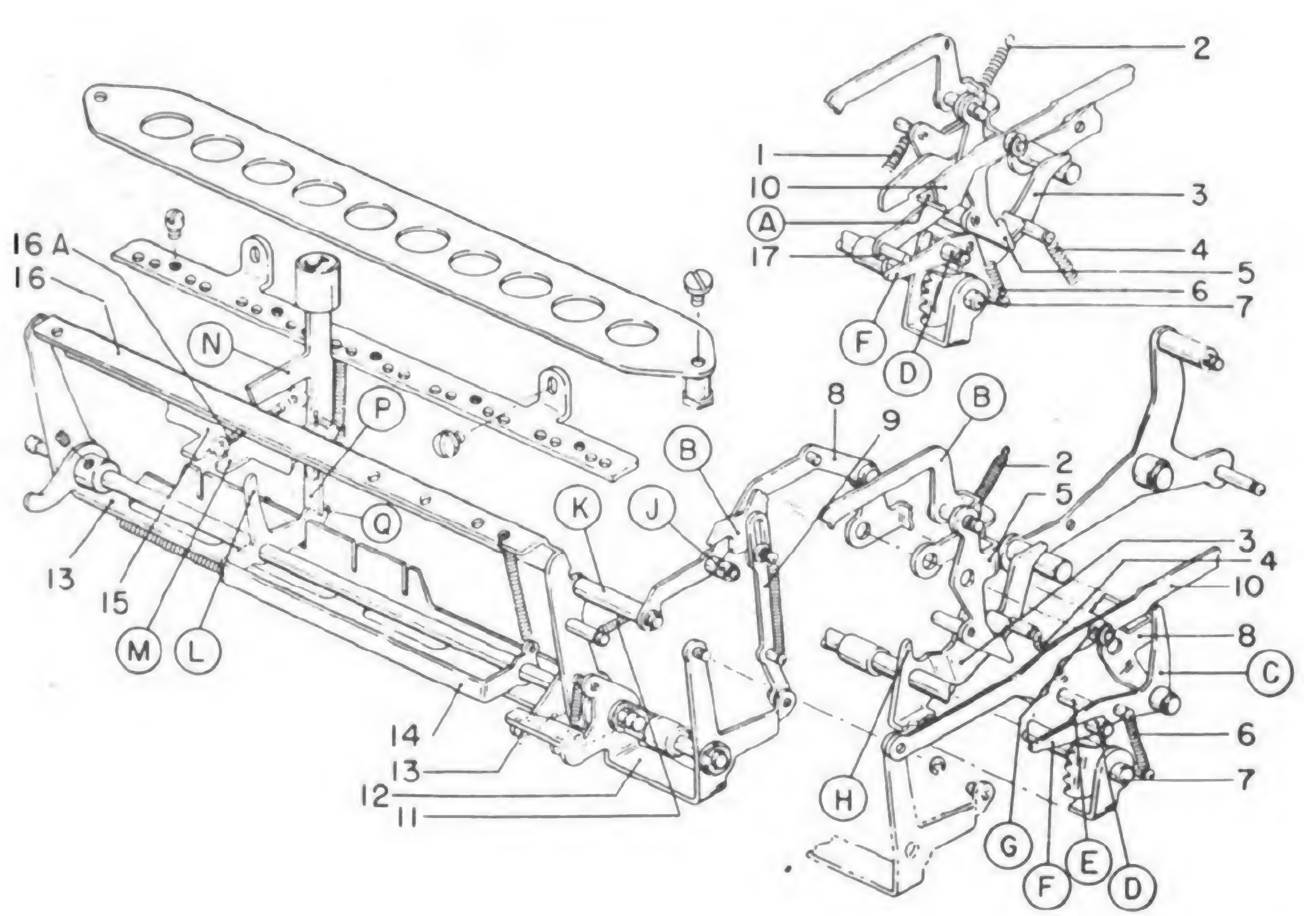


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Figure 14-3.—Multiply key mechanism.

(14) to the right to release extension (Q) from the keystem yielding pawl (P). This movement allows the keystem bellcrank comb (13) to restore and permit the multiply non-print bellcrank latch actuator (21, fig. 14-4) to restore. Stud (X) (fig. 14-4) of the bellcrank latch actuator then releases from extension (Y) of the restoring arm pawl (24) to permit stew (W) to relatch roller (T) of the non-print bellcrank restoring arm (23), through spring (25). The multiply motor drive bellcrank latch (17, fig. 14-3) latches extension (A) on the control connector link (10) to prevent this link and the motor drive control bellcrank (12) from restoring. This action holds pawl (B) behind roller (J) on the keystem lock release arm (8) to prevent the motor control arm latch (5) from relatching the motor drive control arm (3, fig. 14-3) in order to keep the motor running for the last stroke of the multiplier. Roller (G) on the control connector link (10) then holds the control arm (C) above roller (D) to prevent the keystem lock release arm (8) from restoring. This arm, in turn, prevents the multiply key from restoring until the last stroke.

On the stroke next to the last return stroke, arm (F) on the universal drive shaft (7) raises latch (17) to release link (10) and permit it and bellcrank (12) to restore. As bellcrank (12) restores, link (9) moves up to raise pawl (B) from behind roller (J), which action permits spring (2) to move the lower part of latch (R) (fig. 14-4) into a latching position on arm (3).

The multiply non-print bellcrank restoring arm pawl (24) then restores the non-print bellcrank restoring arm (23), and also the restoring multiply non-print bellcrank (22) and the multiply mechanism operating slide (fig.

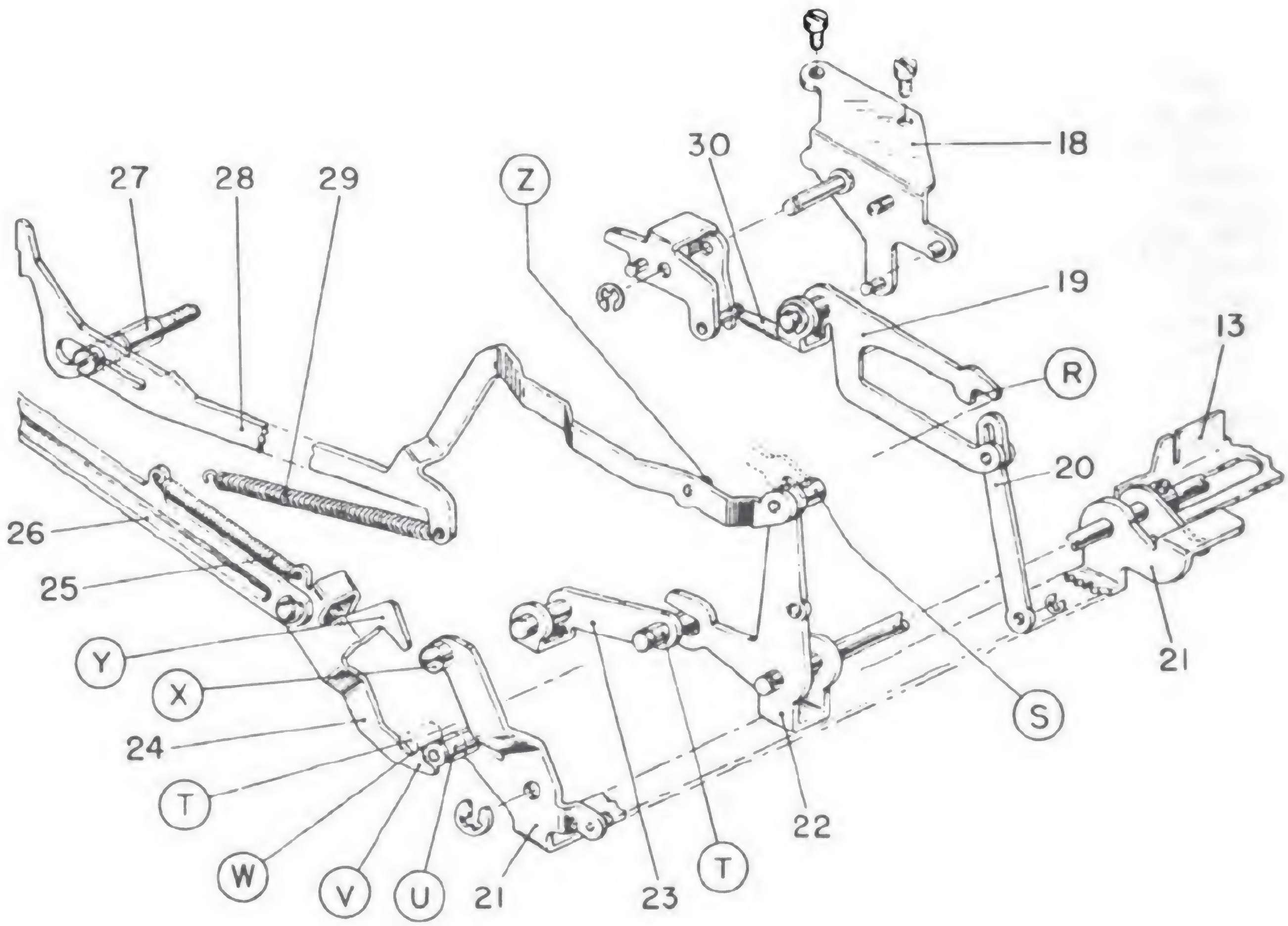

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Figure 14-4.—Multiply key mechanism—Continued.

14-14). Stud (Z) on slide (28) (fig. 14-5) contacts and rotates bellcrank (39) to position link (38) to the right and release retaining pawl (35) from operating slide (15). This action permits slide (15) to restore by means of tension supplied by spring (31). Spring (30) continues the action by lowering step (R) of latch (19) into blocking position on roller (S) to hold the multiply non-print bellcrank (22) in a restoring position for the last stroke.

On the last forward stroke, as arm (F) (fig. 14-3) on the universal drive shaft (7) moves downward, control arm (C) drops behind roller (D). Stud (E) on arm (F) then contacts extension (H) of the motor drive control arm (3) and raises arm (3) by latching over it with latch (5). On the return stroke, roller (D) drives control arm (C) to the rear and moves the keystem lock release arm forward. This action moves the keystem lock bail (16) forward to unlatch the multiply key. The multiply key then restores under its own spring tension, and the motor drive control arm (3) latches with the motor drive control arm latch (5) to stop the motor. The machine also prints and backspaces on this stroke.

Key Restoring Mechanism

The key restoring mechanism of the Model DM99 Remington calculator is shown in figure 14-6. The function of this mechanism is to help to restore a multiply key if pressure is applied to another multiply key when a multiply key is restoring.

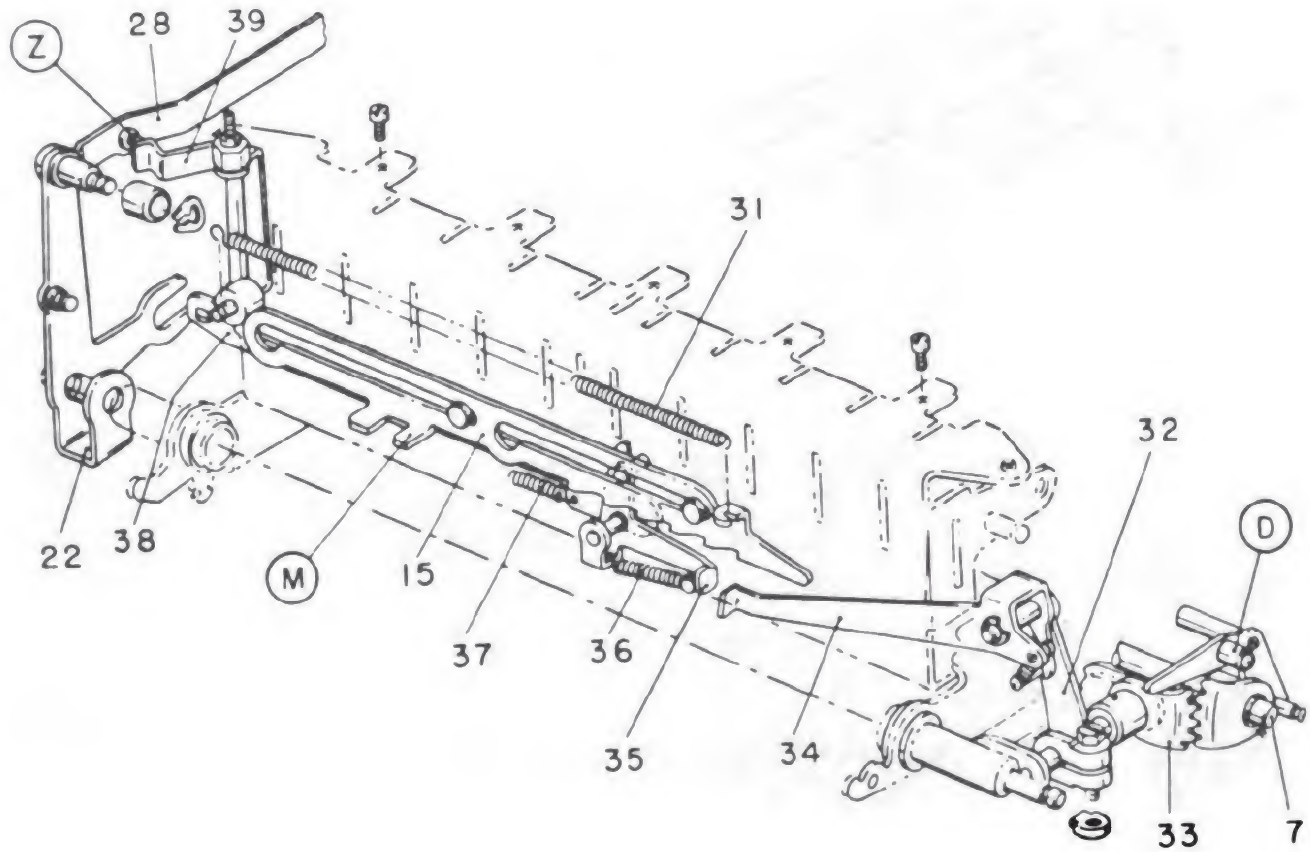

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Figure 14-5.—Multiply key mechanism—Continued.

When the stop section is in the normal position, the blank stroke lock bellcrank (7), which controls arm (C) under stud (A), holds the keystem return bail operating pawl (1) above stud (E) of the keystem return bail arm (12). This action prevents slide (13) from operating during listing operations, except on REPEAT listing operations.

When an item is entered in the stop section, the blank stroke lock bellcrank (7) moves to the rear to permit arm (C) to lower pawl (1) and latch it over stud (E) of the keystem return bail arm (12).

As a multiply key is depressed and link (10) moves to the rear, stud (D) contacts the keystem return bail operating pawl (1) and raises its front extension off stud (E) to prevent operation of the key return slide (13) until the last stroke of each multiplier has been completed. On the last stroke, as link (10) restores, stud (D) permits the front portion of pawl (1) to latch stud (E). As the high point of the motor drive bellcrank pulls the feature key release link (3) to the rear, it also moves (through the feature key latch assembly, (5) the key return bail operating link (2) to the rear and takes with it the key return bail operating pawl (1) mounted on stud (B). This action operates the keystem return bail arm (12) and rotates the keystem return bail (14), which then raises slide (13).

The function of the yield spring (11) is to prevent the throwing of parts out of adjustment, and to prevent breakage, if TOO MUCH pressure is applied to another multiply key, or if a multiply key is blocked and cannot restore.

Short-cut Multiplication Mechanism

Study illustrations 14-7 and 14-8 as you follow the discussion of the short-cut multiplication mechanism (multiply keys 6 through

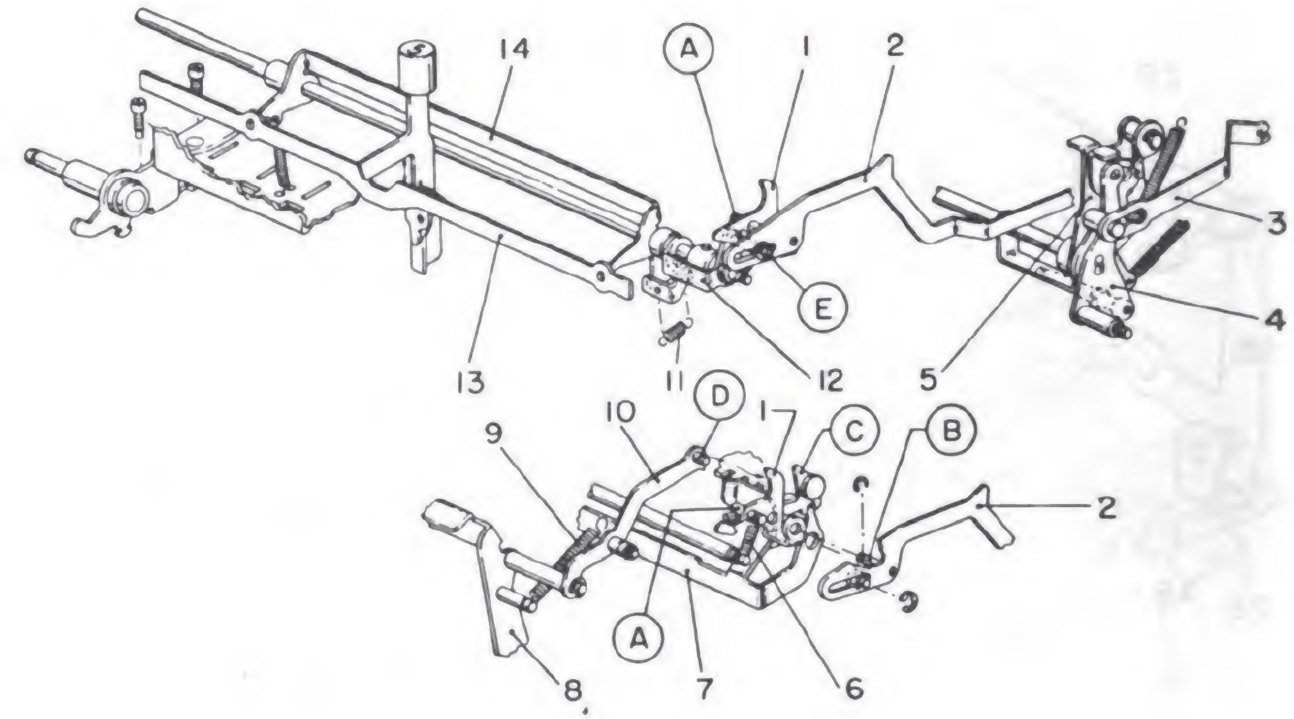

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Figure 14-6. —Key restoring mechanism.

9). Note that numerals through 16 and letters A through Q are used in figure 14-7, and letters R through V and numerals 17 through 26 are used in illustration 14-8.

As a multiply key is depressed (8 illustrated), yielding pawl (H, riveted to the keystem) contacts extension (G) of the negative keystem operating bail assembly (9). Stud (J) of the negative keystem operating bail assembly (9) then positions the keystem operating bellcrank (14), the keystem bellcrank comb (13), the motor drive bellcrank (12), the multiply non-print bellcrank latch actuator (21, fig. 14-8), and the non-print bellcrank (22).

When extension (G, fig. 14-7) moves down, it contacts extension (F) and rotates the negative multiply type drive bail (6). As this bail rotates, the space key bail operating pawl (5) pulls downward on stud (C) of the space key drive bail (4), which then depresses a space stop through space key extension (3). The forward extension of bail (4) raises the control slide latch (7) and permits the stop section control slide (8) to move to the left into step (K) of the control slide latch. This movement permits the stop section (1) to move to the left one space.

As the negative multiply type drive bail (6) moves downward, it causes pawl (L) to pull down on extension (N) of the negative multiply retaining latch (14) to release latch (14) from pawl (13) and permit pawl (13) to drop, so that the fork in its rear extension lies in the path of stud (M).

Operation of the universal drive shaft (12) by the backspace cam drives pawl (13) forward and moves the negative multiply latch release arm link (Q) upward to put spring tension on the negative multiply operating arm latch (15). At the same time, stud (M) contacts pawl (L) and drives it forward (off lip N) and permits latch (14) to restore and block pawl (13). Stud (E) (right side) contacts extension (D) of the space key bail operating pawl (5) and moves the pawl forward and upward to unlatch it from stud (C). This movement permits the space key drive bail (4) and the space key extension (3) to restore. Near the end of the forward stroke, a roller on the backspace cam contacts the negative multiply operating arm (16) to unlatch it from its latch (15).

On the first return stroke, spring (26) (fig. 14-8) rotates arm (16) and causes its

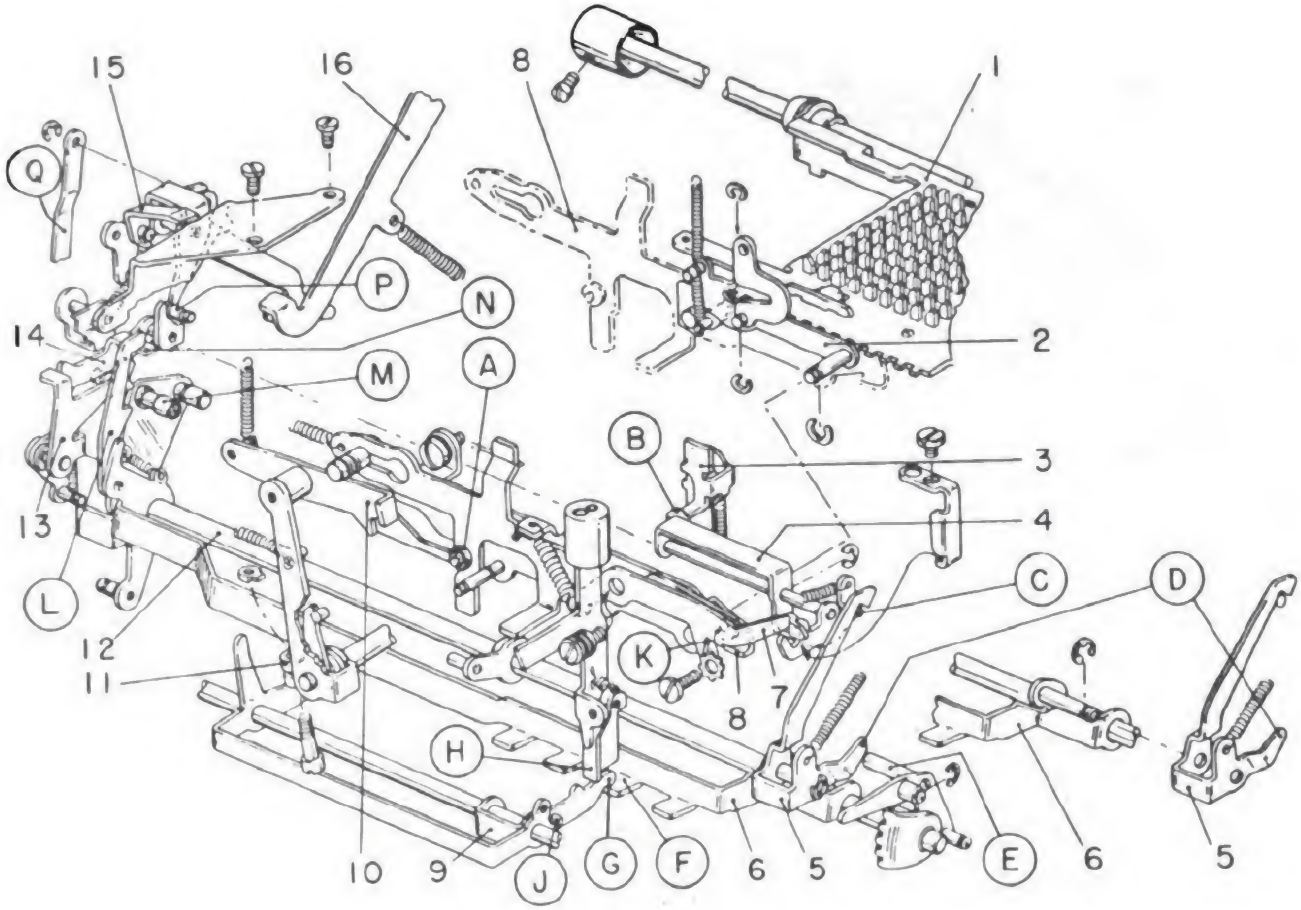

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Figure 14-7.—Short-cut multiplication mechanism.

upper extension to rotate shaft (17). Arm (18) on shaft (17) then raises the subtract arm operation bail (23) and the subtract yield arm (21), and positions the vertical subtract slide (22) in a raised position. Extension (S) on the right arm of shaft (17) then moves to an over-latched position of the subtract latch arm (20) and the machine backspaces. As the backspace pawl (10, fig. 14-7) moves to the right, it contacts roller (A) and moves the stop section control slide (8) to the right and relatches it with the control slide latch (7). This action moves the stop section (1) one space to the right.

On the second forward stroke, the negative multiply operating arm (16, fig. 14-7) relatches with latch (15) and the subtract latch arm (20) (at the same time) holds the subract mechanism in a raised position. The accumulator wheels then revolve to a subtract position for the remainder of the multiplying digit.

On the last stroke of the multiplier, if there is a space in the UNITS column, the machine again backspaces and causes arm (T) on the right end of the backspace shaft (19) to contact latch (20) and unlatch it from extension (S), permitting shaft (17) to restore. This action permits arm (18) to lower the subtract arm operating bail (23), the subtract yield arm (21), and the vertical member (22) of the subtract slide.

If the release key is used, or if there is a significant figure in the units column, the stop section will restore on the last stroke of the multiplier. Roller (V) on arm (25) (right end of the reset gear shaft, (24) then contacts latch (20) to unlatch it from extension (S) and permit shaft (17) and the subtract mechanism to restore.

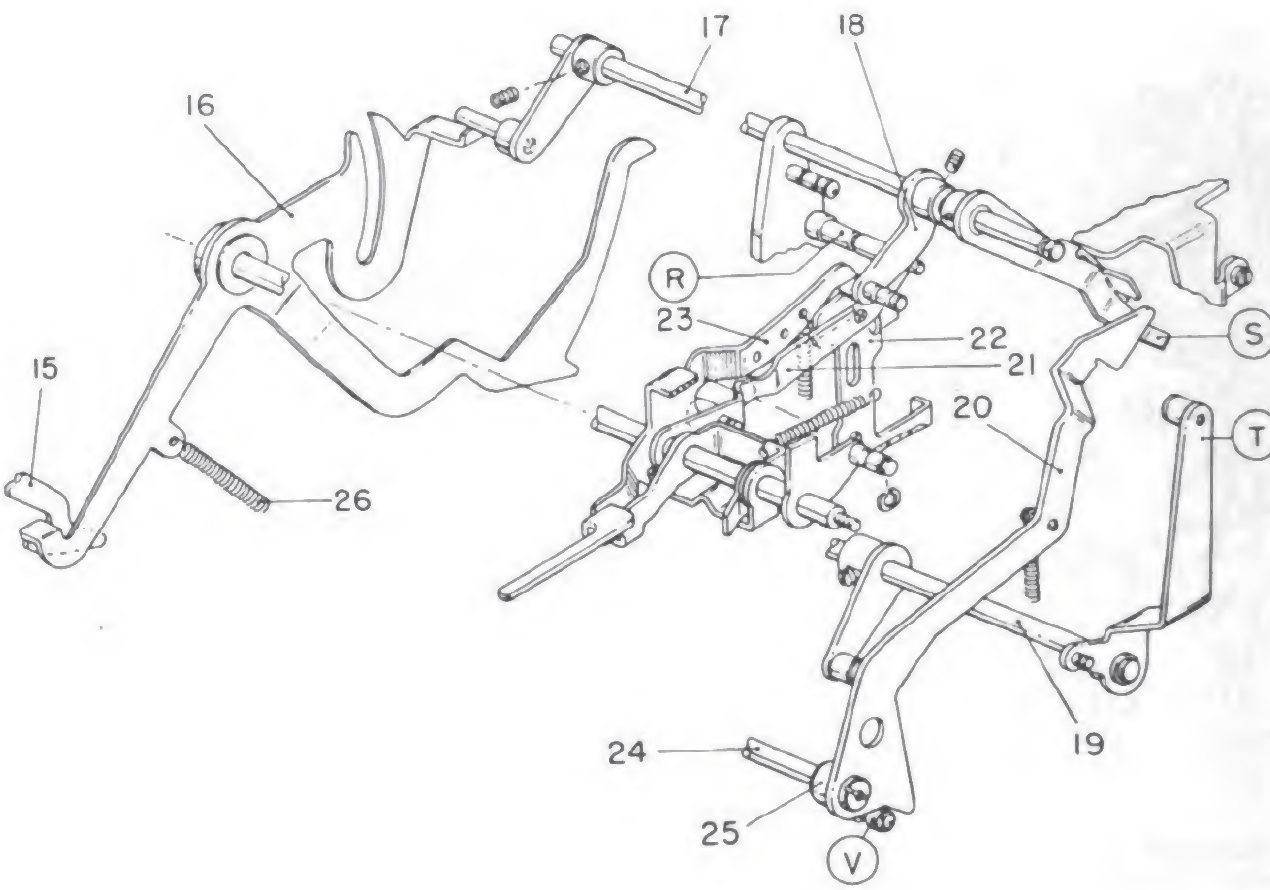

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Figure 14-8.—Short-cut multiplication mechanism—Continued.

Automatic Total Mechanism

The automatic total mechanism is shown in figure 14-9.

When the first multiply key is depressed, the keyboard interlock slide (15) moves to the right to position extension (C) out of the path of extension (D). Note these parts in the circled part of the illustration.

As the UNITS adding rack moves out of the space position, the division control lever operating arm (4) rotates the automatic total multiply latch retaining bail (5) to release the automatic total multiply latch (7), in order that its forward extension may move down and rest on lip (E). Stud (H) in arm (G) contacts the upright portion of arm (9) and raises the arm, thereby causing the camming surface of this arm to contact stud (J) of latch (11). This action drives link (12) rearward, where it latches onto lip (E) with latch (7) to keep the motor running for the rest of the operation.

The motor continues to run until the total stroke is accomplished. As the total slide (16) moves to the rear, it rotates the feature key latch shaft (8) and (through link F) the multiply latch moves upward to unlatch lip (E) and relatch with bail (5). The motor drive control arm latch (11) relatches the multiply motor drive control arm (9) and stops the machine at the end of the stroke.

If the release key is operated during a problem, the release keylever extension (18) contacts arm (A) and latches it in front of latch (B). This action actuates link (1) and (through bail (3) and link 6) releases the automatic total multiply latch-retaining bail (5) from the automatic total multiply latch (7).

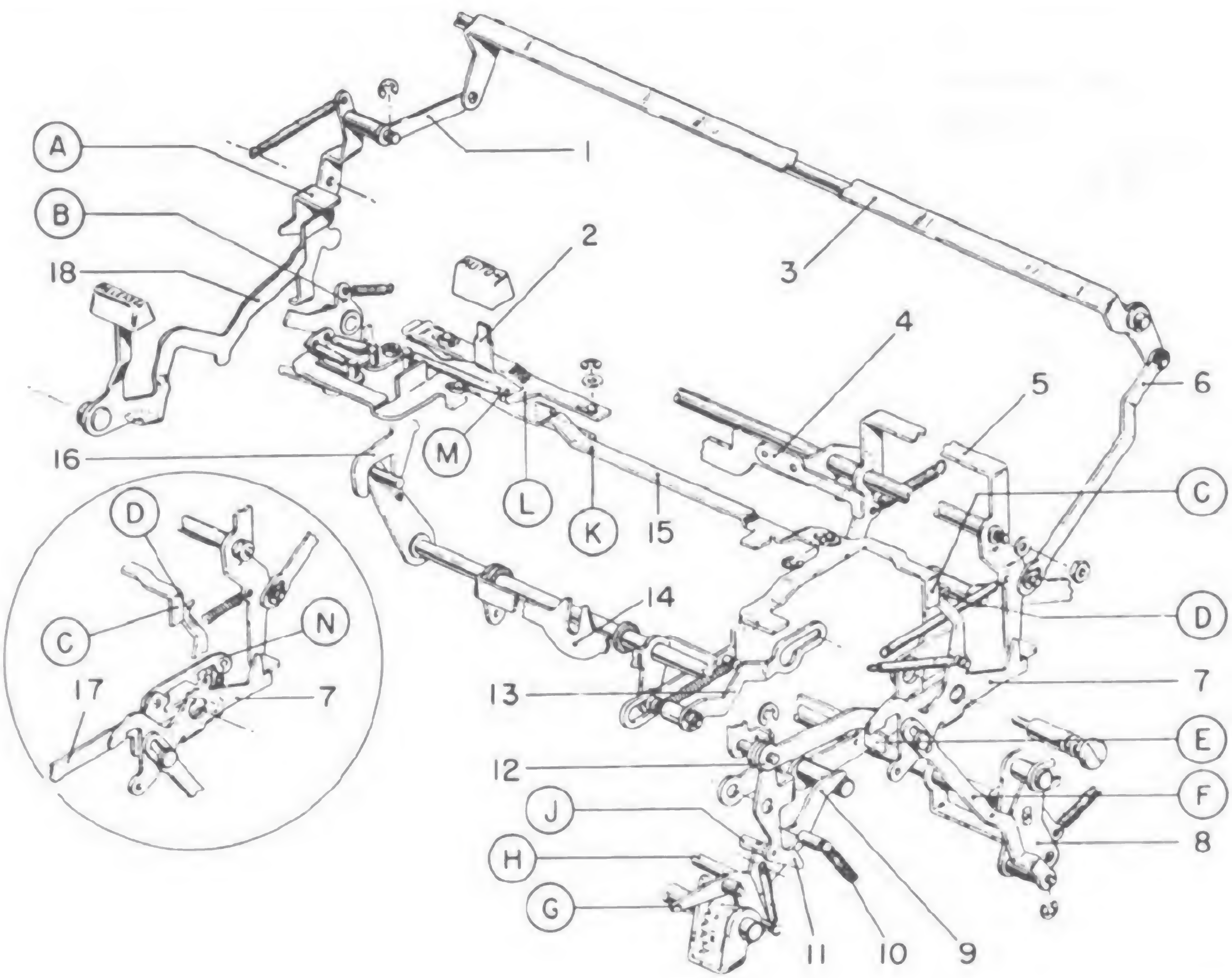

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Figure 14-9.—Automatic total mechanism.

The machine then takes an automatic blank stroke and the total.

Whenever you desire accumulative multiplication, position the automatic total multiply lock slide (2) to the left. This movement positions extension (L) in the path of stud (M) and holds extension (C) in the path of extension (D) to prevent latch (7) from latching lip (E), thereby preventing the machine from totaling. Also, as extension (L) moves into the path of stud (M), extension (K) cannot move over the universal bar. This action enables you to set up a new problem in the machine, even though an automatic total has not been taken.

The function of the disengaging pawl (N) on the control connector link (17) is to normalize the automatic total multiply latch (7) in the event you used the release key before you entered the multiplicand on the keyboard. If you used the release key in this manner and the automatic total multiply latch was not normalized, the machine would take an automatic blank stroke and total after the first multiplier. If the release key is used after the multiplicand has been entered in the keyboard, the machine clears in the usual manner, because arm (A) is latched in front of latch (B).

The function of link (13) (connected to the decimal operating bail, (14) is to raise the plunger when the decimal key is depressed. This action prevents the stop section from clearing out when discount multiplication is performed.

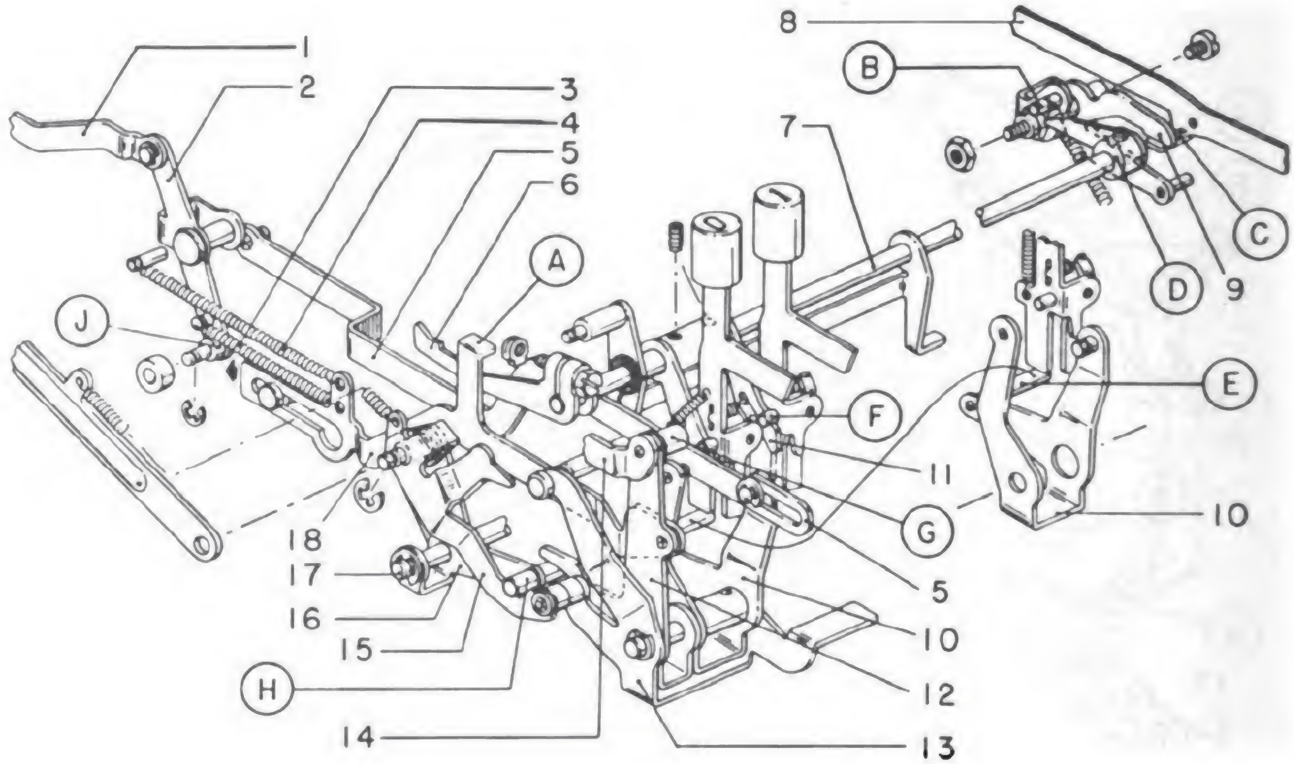

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Figure 14-10.—Non-print mechanism.

Nonprint Mechanism

Illustration 14-10 shows the non-print mechanism of the Model DM99 calculator.

When multiply keys 1 through 5 (which do not require short-cut operations) are used, the Model DM99 calculator cycles the same number of strokes as the value of the multiplier. For example, if you multiply with the figure 1, the machine takes only 1 stroke, and so forth.

As explained previously in this chapter (fig. 14-3), for multiply keys 2 through 9, the operation of the keystem bellcrank (14) positions extension (L) in the path of the keystem bellcrank operating slide (15) and rotates the keystem bellcrank comb downward to actuate the multiply non-print bellcrank latch actuator (13) and to release the non-print bellcrank (12). As this bellcrank moves to the rear, spring (4) pulls the multiply non-print slide (18) to the rear, where its rear portion contacts inner roller (J) on the non-print bellcrank (2) to position the non-print linkage (1) toward the front of the machine.

On the next to the last forward stroke, extension (M) (fig. 14-3) of the keystem bellcrank operating slide (15) contacts extension (L) of the keystem bellcrank (14) to release extension (Q) from the keystem and permit it and the bellcrank comb (13) to restore. This action also allows the multiply non-print bellcrank latch actuator (13) (fig. 14-10) to restore. The multiply non-print bellcrank restoring arm pawl (15) is then allowed to latch with roller (H) on the multiply non-print restoring arm (16). On the next to the last return stroke, pawl (15) restores the non-print bellcrank restoring arm (16), thereby restoring the non-print bellcrank (12) and the non-print slide (18). As the non-print slide (18) restores, spring (3) restores the non-print linkage (1) and sets up the machine for a printing and backspacing operation on the last stroke. When the 0 or 1 multiply key is depressed, stud (F) (only in keystems (0 and 1)

on the keystems contacts the zero key retaining mechanism drive arm (11) and rotates the motor drive bellcrank latch retaining shaft (7) to accomplish the following:

1. Arm (D) at the right end of shaft (7) moves up to block stud (B) and prevent the multiply motor drive bellcrank latch (9) from latching lip (C) of the control connector link (8). This action permits the motor drive control arm (3, fig. 14-3) to relatch on the first stroke and prevent the machine from taking more than one operation.

2. The multiply non-print bellcrank slide retaining arm (6, fig. 14-10), on the left end of shaft (7) rises to block extension (A) of the multiply non-print bellcrank slide (18), thereby preventing it from actuating the non-print bellcrank (2) and the non-print block arm assembly (1). The machine will therefore print on this stroke. Positioned to the rear, the multiply mechanism operating slide holds the backspace control pawl to the rear long enough to permit operation of the backspace mechanism on this stroke.

Because no values are changed in a multiplication problem when you multiply by zero, the non-add mechanism must be operated whenever you use the 0 multiply key, as follows: When you depress the 0 multiply key, you actuate the non-add bellcrank (10) and (through the multiply non-add bellcrank link, (5) position the non-add mechanism for a non-add operation. NOTE: Stud (E) on the multiply non-add bellcrank helps to accomplish this action.

Multiplier and Quotient Rack

The multiplier and quotient rack in the Model DM99 Remington calculator is illustrated in figures 14-11 and 14-12. Note that numerals 1 through 16 and letters A through P are used in figure 14-11, and that numerals 17 through 38 and letters R through Y are used in figure 14-12.

Type on the right side of the multiplier and quotient rack (M & Q rack) are used for multiplying. Their order of arrangement (from top to bottom) is: 0 - 1 2 3 4 5 9 8 7 6.

The M & Q rack normally rests in the decimal printing position. Because all multiply keys do not set up the same condition in the machine, three initial positions of the M & Q rack are necessary in order to obtain the proper printing position. The conditions are as follows:

1. <u>Multiply keys 1 through 5.</u>—When multiply keys 1 through 5 are used, there are no extra strokes on the machine. Because printing takes place before the M & Q rack feeds, the operator must position the M & Q rack up ONE SPACE in order to obtain correct printing.

When the operator depresses a multiply key and the non-print bellcrank (8, fig. 14-11) rotates, the multiply mechanism which operates slide (7) moves to the rear to rotate the multiply cam link limit arm (11) and position step (11A) in the path of extension (12A). Extension (J) of slide (7) then contacts the retaining arm (13) and unlatches the limit latch (4). Roller (L) of the limit latch limits against step (14A) of arm (14) and positions the lower extension of the limit latch in the path of extension (C) of the M & Q rack to prevent the M & Q rack from overthrowing its initial one-space movement.

As the main shaft moves forward, the negative multiply type drive cam link (12) moves down through the tension of spring (9) until (12A) limits on (11A). Extension (G) of link (12) then contacts stud (F) of the negative multiply type drive shaft arm (3A) to rotate shaft (3) and cause arm (D) (pinned to shaft (3) to position the M & Q rack up ONE space. The multiply repeat arm (20, fig. 14-12) on the right end of shaft (3) then rotates the repeat shaft arm (21) and raises the plunger (22) to prevent the stop section from clearing.

Near the end of the forward stroke, the backspace cam (1, fig. 14-11) contacts extension (K) of the type carrier retaining pawl lock hook (16, fig. 14-11) and unlatches the type carrier retaining pawl (5). The retaining pawl, (5) then moves into the teeth of the M & Q rack under tension of spring (6). At the same time, extension (M) contacts extension (N) of limit latch (4) and moves (4A) out of the path of extension (C) of the M & Q rack, and the outer extension (P) of limit latch (4) latches over latch (15). This sequence of operation is very important; for if the limit latch (4) is not moved out of blocking position FIRST, the M & Q rack will NOT feed.

When the backspace cam contacted extension (K) of lock hook (16), it permitted the negative multiply type arm latch (2) to move to the rear under tension of spring (2A). Then the lower extension of the multiply repeat arm (2) moved into latching position with arm (3A), and held the multiply repeat arm (20) against the repeat arm shaft (21, fig. 14-12) to keep the plunger (22) in a raised position and prevent the stop

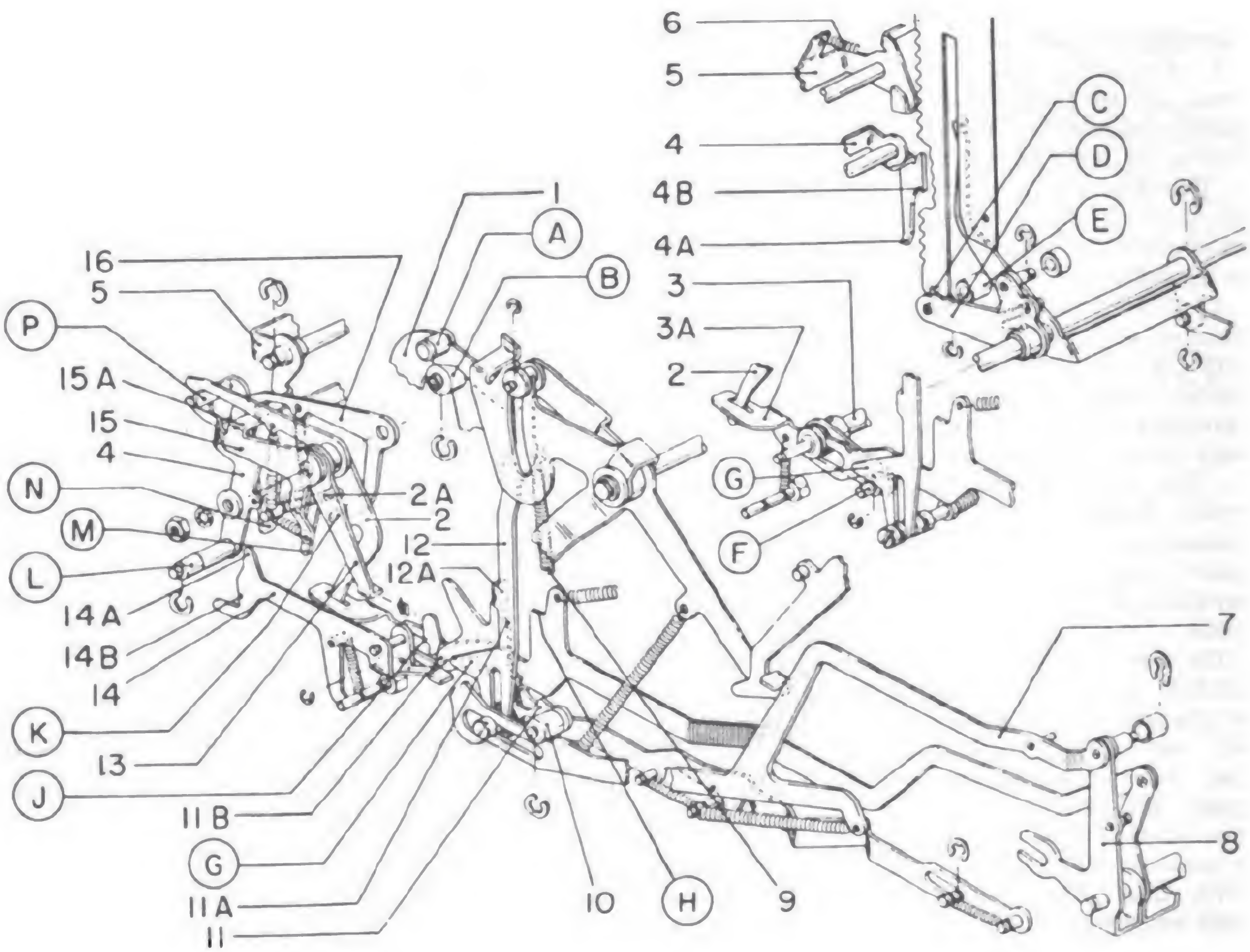

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Figure 14-11.—M and Q rack.

section from clearing. The machine continues to operate and, on the stroke next to the last forward stroke, extension (M, fig. 14-3) contacts extension (L) of the keystem operating bellcrank (14, fig. 14-3) and releases the keystem bellcrank comb (13). This action permits the non-print bellcrank latch actuator (21, fig. 14-4) to restore and the restoring arm pawl (24) to latch with roller (T) on the non-print bellcrank restoring arm (23).

On the next to the last return stroke, the restoring arm pawl (24, fig. 14-12) restores the non-print bellcrank restoring arm, the non-print bellcrank (8, fig. 14-11), and the multiply mechanism operating slide (7). As this slide (7) moves forward, limit arm (11) restores and retaining arm (13) restores to a latching position of limit latch (4). Arm (13) also contacts extension (15A) to lower latch (15).

As the machine prints on the last stroke, the type carrier retaining pawl release hook picks up the retaining pawl (5) and relatches it with lock hook (16) (fig. 14-11). Extension (K) of lock hook (15) then unlatches latch (2) from (3A) and permits shaft (3) and plunger (22) to restore. Outer extension (P) of limit latch (3) is latched with retaining arm (13).

2. Multiply keys 6 through 9.—As you learned previously, the machine operates by the short-cut method when multiplier digits 6 through 9 are

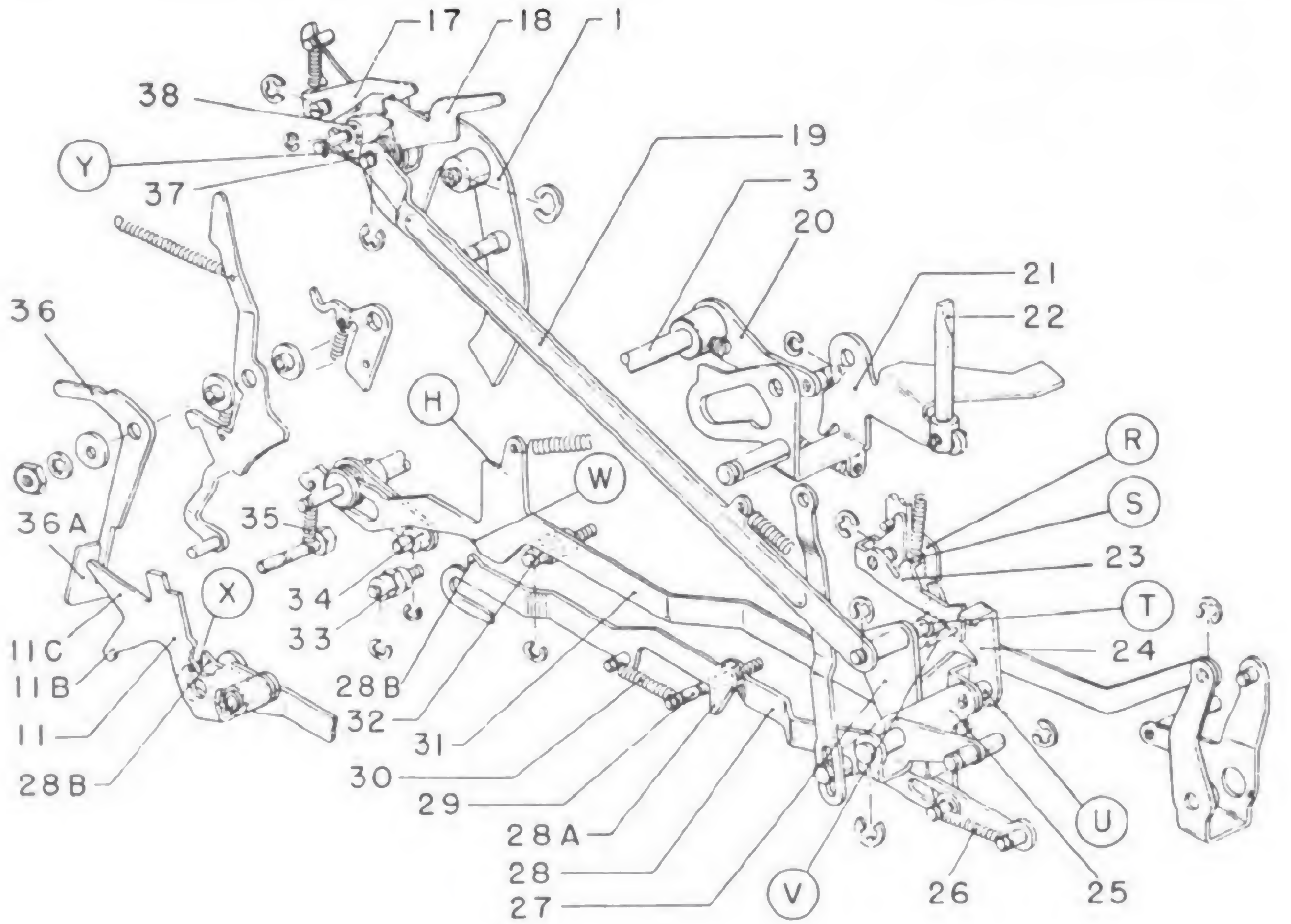

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Figure 14-12.—M and Q rack (cont.).

used. When multiplying by 9, for example, the machine takes two strokes. In order to obtain proper printing position, the M & Q rack must be positioned up initially five spaces; from there on it is fed one space on each operation.

When a multiply key 6 through 9 is depressed, bellcrank (8), slide (7), limit arm (11), retaining arm (13), and limit latch (4) are positioned in the same manner as the multiply keys for the 1 through 5 operation just explained. The negative multiply motor drive engaging pawl (R) contacts lip (S) of the negative multiply motor drive retaining latch (23) and releases the latch from pawl (24) to permit the rear of extension (24) to drop in front of stud (T) (fig. 14-12). As the main shaft moves forward, the backspace cam (1) drives the universal drive link (19) forward and causes stud (T) to move pawl (24) forward and rotate the negative multiply motor drive arm (25) to move its lower extension to the rear. Yield spring (26) allows the negative multiply motor drive slide (28) to move rearward and cause its rear extension (28B) to contact stud (X) of the multiply cam link limit arm (11), thereby moving the limit arm to the rear far enough to have step (11A) out of the path of extension (12A) of link (12). Extension (11C) holds the outer pawl (36) to the rear to permit backspacing on the first return stroke.

Extension (11B) (fig. 14-11) contacts the forward extension of the type carrier limit latch control arm (14) and positions roller L from the (14A) to the (14B) position. This action moves (4A) out of the path of (C) and places

(4B) in the path of (C) to prevent the M & Q rack from overthrowing its initial five-space movement.

The negative multiply type drive cam link (12) then moves down and extension (G) contacts stud (F) (fig. 14-11) to rotate shaft (3) and cause arm (D) to raise the M &· Q rack five spaces. The multiply repeat arm (20) on the right end of shaft (3) contacts the repeat shaft arm (21, fig. 14-12) and raises plunger (22). Near the end of the forward stroke, the backspace cam (1) contacts extension (K) of lock hook (16, fig. 14-11) and releases retaining pawl (5). Extension (M) of pawl (5) then contacts extension (N) of latch (4) and moves (4B) out of the path of (C). At the same time, extension (K) permits latch (2) to move into latching position with (3A). The outer extension (P) of limit latch (4) latches over latch (15).

Stud (T) of the universal drive shaft arm (27, fig. 14-12) contacts the negative multiply motor drive engaging pawl (R) and drives it forward off lip (S) of retaining latch (23), which then restores to a blocking position of the negative multiply mechanism motor drive pawl (24).

On the first return stroke, the negative multiply motor drive slide (28) restores through the tension of spring (30) and permits limit arm (11) to restore to the one-space position. The outer pawl (36, fig. 14-12) moves into a latching position to receive the backspacer and control arm (14) (fig. 14-11) then restores.

On the stroke next to the last forwarding stroke, extension (M) (fig. 14-3) of the keystem bellcrank operating slide (15, fig. 14-11) contacts extension (L) of the keystem operating bellcrank (14) and releases the keystem bellcrank comb (13). This action permits the non-print bellcrank latch actuator (21) (fig. 14-4) to restore, allowing the non-print bellcrank restoring arm pawl (24) to latch with roller (T) on the non-print bellcrank restoring arm (23).

On the stroke next to the last return stroke, the restoring arm pawl (24) restores the non-print bellcrank restoring arm (23), the non-print bellcrank, the multiply mechanism operating slide (7). As this slide moves forward, limit arm (11) restores and retaining arm (13) also restores to a latching position of limit latch (4).

On the last stroke, as the machine prints, the type carrier retaining pawl release hook picks up the retaining pawl (5) and relatches it with lock hook (16). This action causes extension (K) of (16) (fig. 14-11) to unlatch (2) from (3A) and permit shaft (3) and plunger (22) (fig. 14-12) to restore. Outer extension (P) of limit latch (4) then becomes latched with retaining arm (13).

3. Multiplying by 0.—In order to get the 0 into printing position, lower the M & Q rack one space, as follows: In its normal position, the M & Q rack rests on roller (E) (fig. 14-11) of the negative multiply type drive shaft assembly (3) (fig. 14-12), which normally is held in position by roller (34), and limits against the multiply zero type drive slide (31, fig. 14-12). When the zero multiply key is depressed, slide (31) moves to the rear and slope (W) permits the negative multiply type drive shaft (3) to rotate under tension of spring (35) to lower the M & Q rack one space to the zero printing position.

As the multiply zero type drive slide (31) moves to the rear, extension (H) of the slide is positioned under extension (12A) of the negative multiply type drive cam link (12) to prevent the M & Q rack from raising.

4. Negative multiply type drive cam return pawl.—The function of the negative multiply type drive cam return pawl (18, fig. 14-12) is to pick up and restore the negative multiply type drive cam link (12) (fig. 14-11) immediately following the return stroke to enable the stop section to restore when you are multiplying by (1).

If a significant figure is in the units column, or if the release key is used, the operation is as follows: As the backspace cam (1) (fig. 14-12) moves down, the negative multiply type drive cam return pawl moves down with it. The step of this pawl then moves under roller (A) at the top of the negative multiply type drive cam link (12) through spring (37) (fig. 14-12). On the return stroke, as the backspace cam restores, the step of pawl (18) picks up roller (A) and restores the negative multiply type drive cam link (12) at the beginning of the return stroke. This action causes extension (G) of cam assembly (12) to release stud (F) to allow shaft assembly (3) and the multiply repeat arm (20) to restore at the same time, thereby lowering plunger (22) and permitting the stop section to clear.

5. Negative multiply type drive cam return pawl latch.—If the negative multiply type drive cam return pawl (18) is not latched by the negative multiply type drive cam return pawl

(17, fig. 14-12) at the beginning of the first forward stroke of a short-cut multiplier, pawl (18) gets under roller (A) of the negative multiply type drive cam link (12). This action then blocks the travel of cam assembly (12) and the M & Q rack moves to the No. 1 printing position instead of the No. 5 printing position.

6. Auxiliary type carrier limit arm latch.—The purpose of the auxiliary type carrier limit arm latch (15) is to relatch the type carrier limit latch (4, fig. 14-11) at the end of the forward stroke during multiplication by one to prevent limit latch (4) from moving into the path of extension (C) on the M & Q rack as it is fed on the return stroke. This is necessary because slide (7) restores on the return stroke rather than on the forward stroke and prevents the type carrier limit latch retaining arm (13) from latching with limit latch (4).

The purpose of stud (V) on the negative multiply retaining latch (23, fig. 14-12) is to prevent this latch from jarring off and releasing the negative multiply type drive pawl (24). If latch (23) did jar off pawl (24) and the machine operated without multiply non-print bellcrank (8, fig. 14-11), stud U in the upper portion of the negative multiply motor drive arm (25) would limit on top of the form in the rear portion of bellcrank (8), thereby causing locking of the machine, straining of parts, and releasing of adjustments.

Take a look now at the M & Q rack snubber arm assembly, illustrated in figure 14-13. This arm assembly (5) prevents the M & Q rack (3) from bouncing when it restores to its rest position. The snubber arm pivots on the hammer trip shaft (4) and is held in position by spring (6), with the angular extension (B) just above the lower extension (C) of the M & Q rack. When this rack moves upward, it cams the snubber arm to the rear; and the tension of the snubber arm (5) spring is sufficient to prevent the M & Q rack from bouncing as it normalizes. NOTE: Tension of this spring is not strong enough to prevent upward movement of the M & Q rack.

Mult Total Key Mechanism

The mult total key mechanism is illustrated in figures 14-14 and 14-15. Numerals 1 through 16 and letters A through N are used in figure 14-14, and numerals 17 through 37 and letters N through W are used in figure 14-15.

The mult total key mechanism simplifies multiplication by allowing the operator of the machine to use space and memory keys to set spaces to the right of the multiplicand instead of mentally indexing the multiplicand digits and then depressing the space key for each space desired. A mechanism for eliminating zero print to the right of the product on the total operation is also included with this mechanism.

When the multiplicand is entered in the stop section, the blank stroke lock bellcrank (11, fig. 14-14) ROCKS to bring the outer credit balance block arm connecting link (2) to the front of the machine to release extension (A) from the mult total keystem latch (7) and allow it to rest against extension (D) of the mult total keystem (1).

If the mult total key is depressed, screw stud (N) is moved down to permit the hammer block slide latch drive pawl (18, fig. 14-15) to latch over roller (W) on the hammer block slide latch drive arm (17). At the same time, the mult total keystem pawl (3, fig. 14-14) contacts stud (B) and rotates the space-over bellcrank shaft arm (4). Extension (V) (fig. 14-15) on the space-over bellcrank shaft arm (4) drives the non-add link (21) to the rear and positions the non-add mechanism. The space-over bellcrank shaft arm (4) also moves the mult total link (19) to the rear and positions arm (A) in front of latch (B), which sets up the automatic total mechanism. This action permits the stop section to clear so that the machine can take an automatic blank stroke and total. Extension (H) (fig. 14-4) on the left arm of the space-over bellcrank shaft arm operates the negative mult type drive bail (12) and the negative mult cut-out arm (13, fig. 14-14). As bail (12) rotates, the space key bail operating pawl (5, fig. 14-7) rotates; and the space key operating bail (4), which depresses a space stop and escapes the stop section one space to the left. Extension (F) (fig. 14-4) on the right end of bail (12) contacts stud (G) on the motor drive control arm latch (10) and releases the motor drive control arm (9) to trip the motor. As the negative mult cut-out arm (13) is operated, it moves the negative mult motor drive engaging pawl (M) forward to prevent the setting up of the short-cut mechanism. The mult total keystem (1) becomes latched with the mult total keystem latch (7) to hold the parts in position.

As the main shaft moves forward, the hammer block slide latch drive pawl (18)

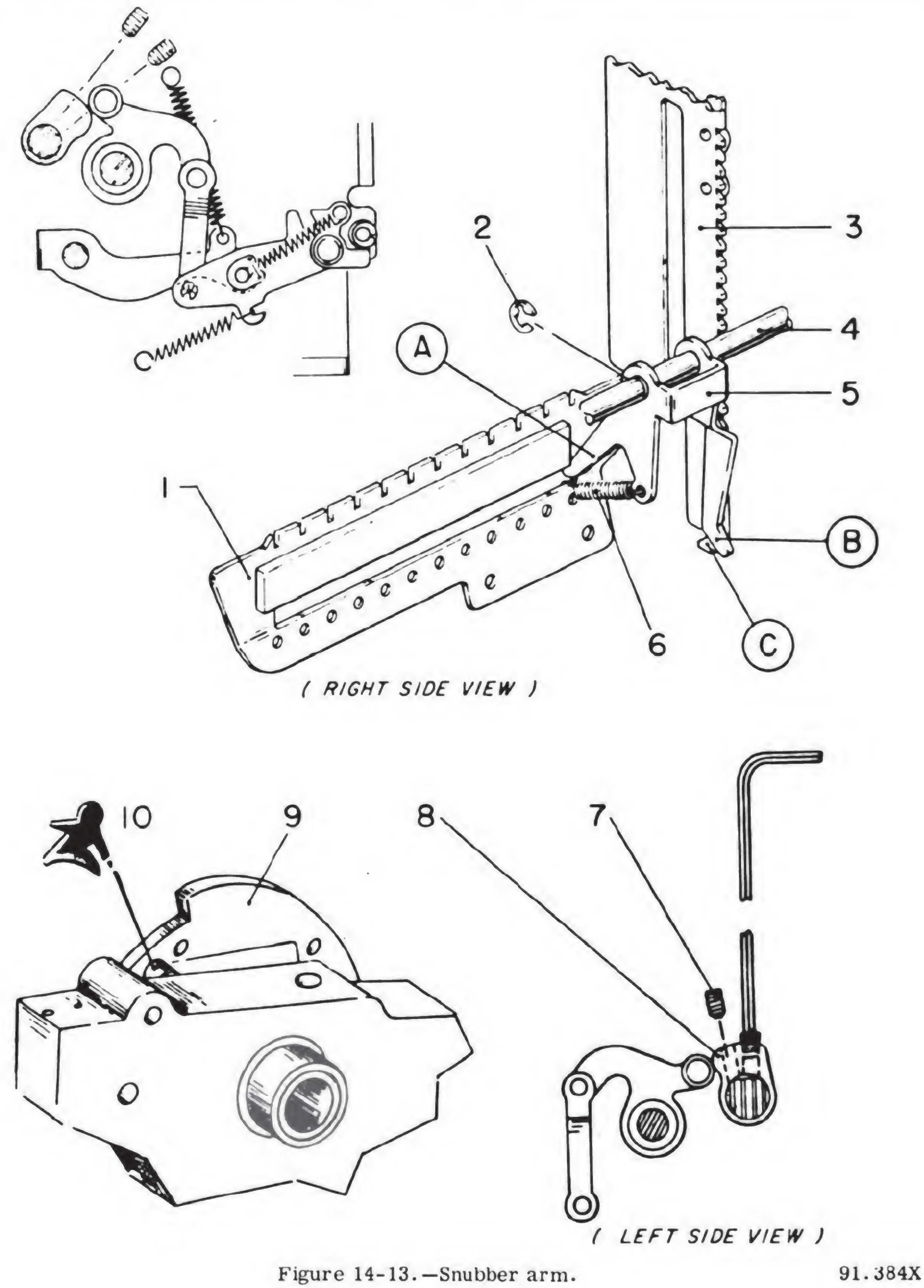

Figure 14-13.—Snubber arm. 91.384X

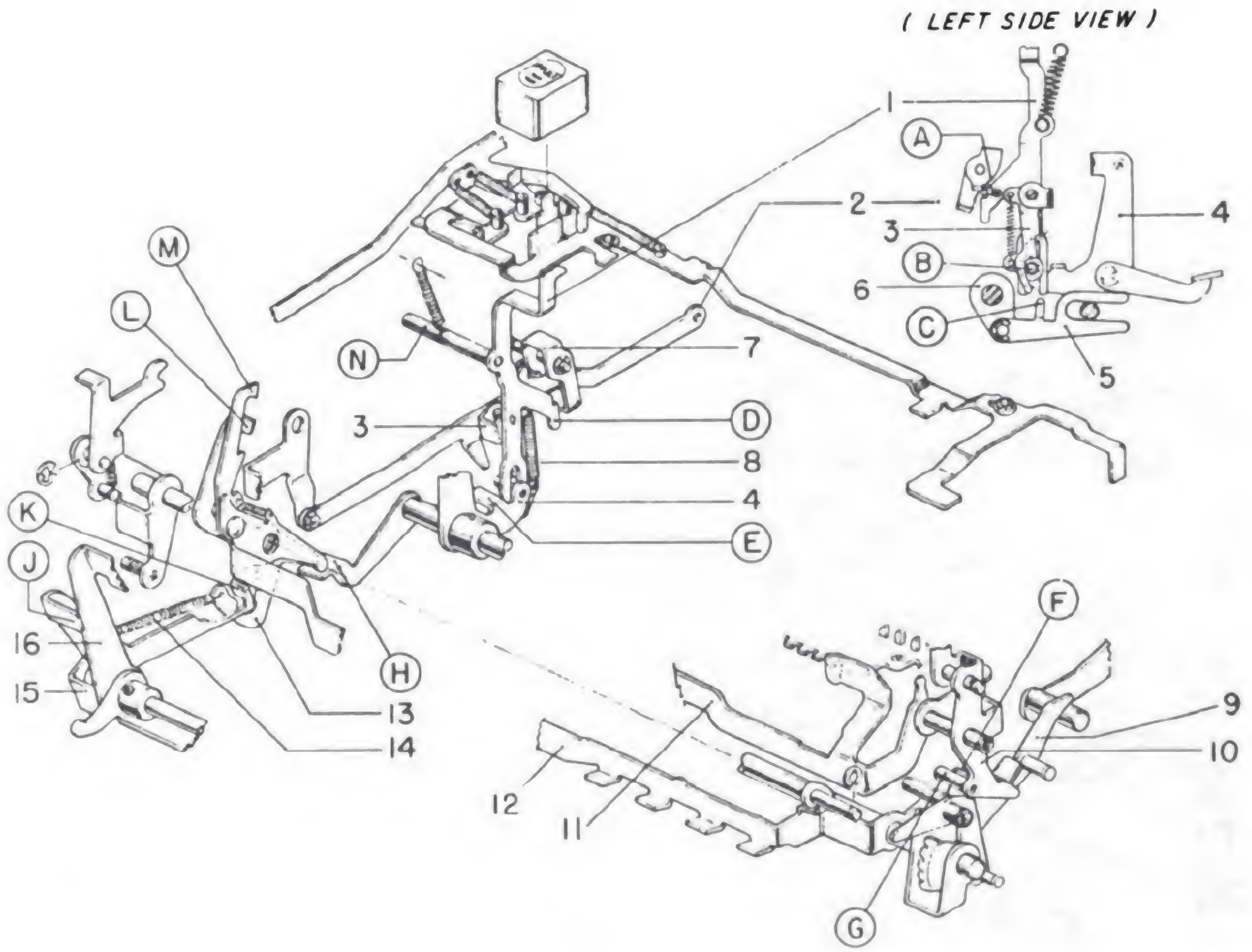

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Figure 14-14.—Mult total key mechanism.

mounted on the left universal shaft arm (37, fig. 14-15) contacts roller (W) to rotate the hammer block slide latch drive arm (17) and the hammer block slide latch pivot shaft (34) forward. The arms (32) pinned to the pivot shaft (34) lower the latch release bail shaft (33) away from the front extensions (Q) on the hammer block slide latches (24), to permit the hooked portion (3) to engage the ears (R) on the hammer block slides (26) when the accumulator racks (27) are in the space position, or rest on the ears (R) if the accumulator racks (27) are beyond the space position. At the same time, the hammer block slide latch bail (23) is positioned above extensions (Q) of latches (24) engaged with the slides (26), (Q), disengaged from slides (26).

The hammer block slide latch pivot shaft (34), the hammer block slide latch bail (33), and the hammer block slide latches (24) remain positioned by the pivot shaft latch (31) until the total stroke is accomplished. This prevents unnecessary zero printing to the right of the product during total operations. At the end of the forward stroke, extension (C, fig. 14-14) on the mult latch kick-off link (5) contacts and releases the mult total keystem pawl (3) from stud (B) on the space-over bellcrank shaft arm (4). This action permits the space-over bellcrank shaft arm (4), the negative mult type drive bail (12), the negative mult cut-out arm (13), the non-add link (21, fig. 14-15), and the mult total link (19) to restore.

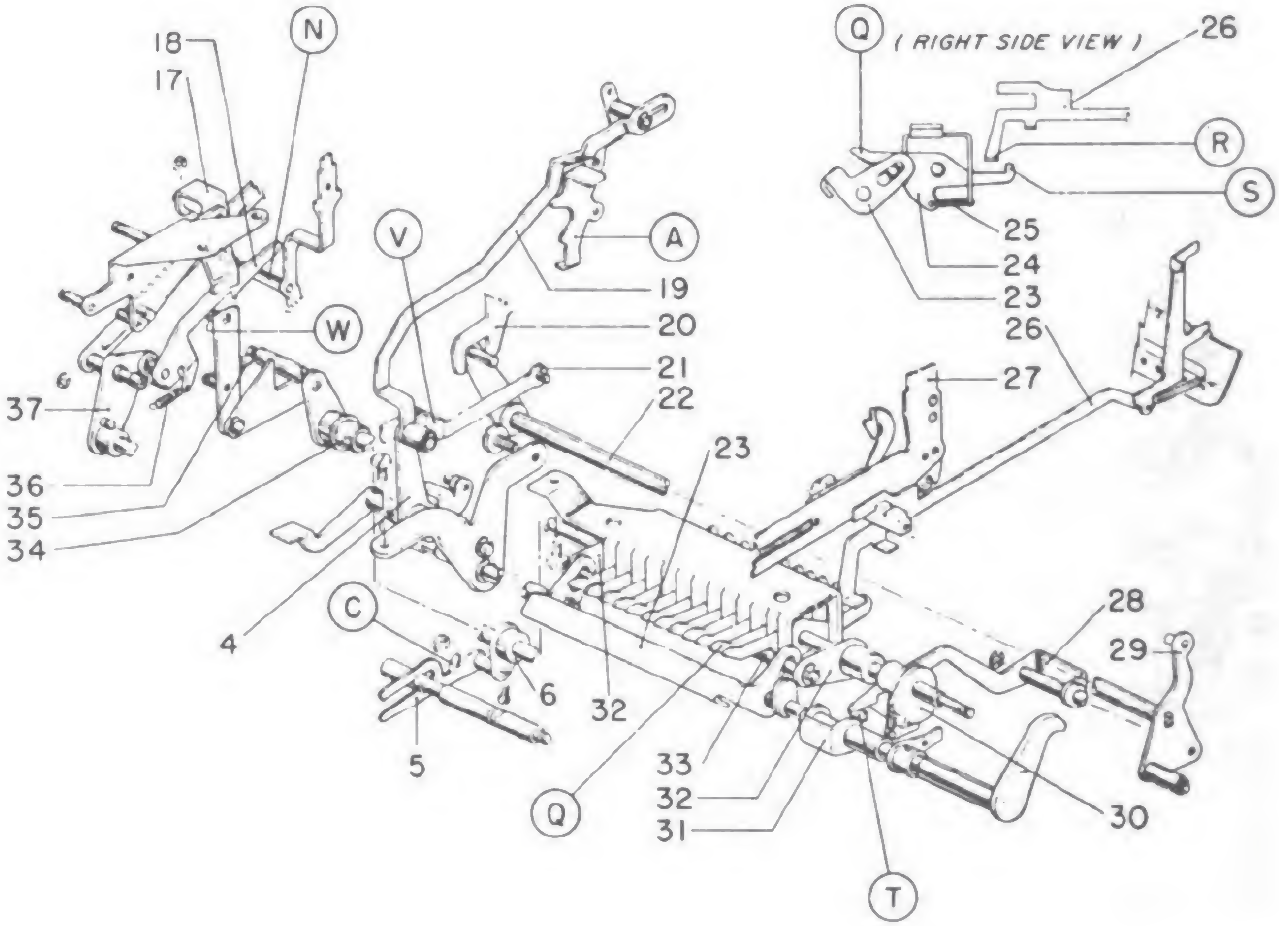

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Figure 14-15. —Mult total key mechanism—Continued.

On the return stroke of the main shaft, the machine neither prints nor adds, and it clears the stop section. As the stop section restores, the blank stroke lock bellcrank (11, fig. 14-14) rocks forward and moves the outer credit balance block arm link (2) to the rear. Extension (A) on link (2) unlatches the mult total keystem latch (7) from the mult total keystem (1) and allows this keystem and the hammer block slide latch drive pawl (18, fig. 14-15) to restore.

During the forward stroke of the total stroke, the total slide (20) moves to the rear and rocks the feature key latch shaft (22). Through the right features key shaft arm (29), the total release pawl (28) latches over ear (T) on the pivot shaft latch (31). On the return stroke, as the total slide (20) restores, the total release pawl (28) unlatches the pivot shaft latch (31) from the pivot shaft latch arm (30, fig. 14-15) and permits shaft (34), the latch release bail shaft (33), the hammer block slide latch bail (23), and the hammer block slide latches (24) to restore through the tension of spring (35). At the same time, the mult latch kick-off link (5) (fig. 14-14) restores to permit the mult total keystem pawl (3) to move over stud (B) in the space-over bellcrank shaft arm (4), through spring (8).

Interlocks

There are 8 different interlocks in the mechanism of a Model DM99 Remington calculator. Refer to figures 14-16 and 14-47 as you study the operation of these interlocks. Note that

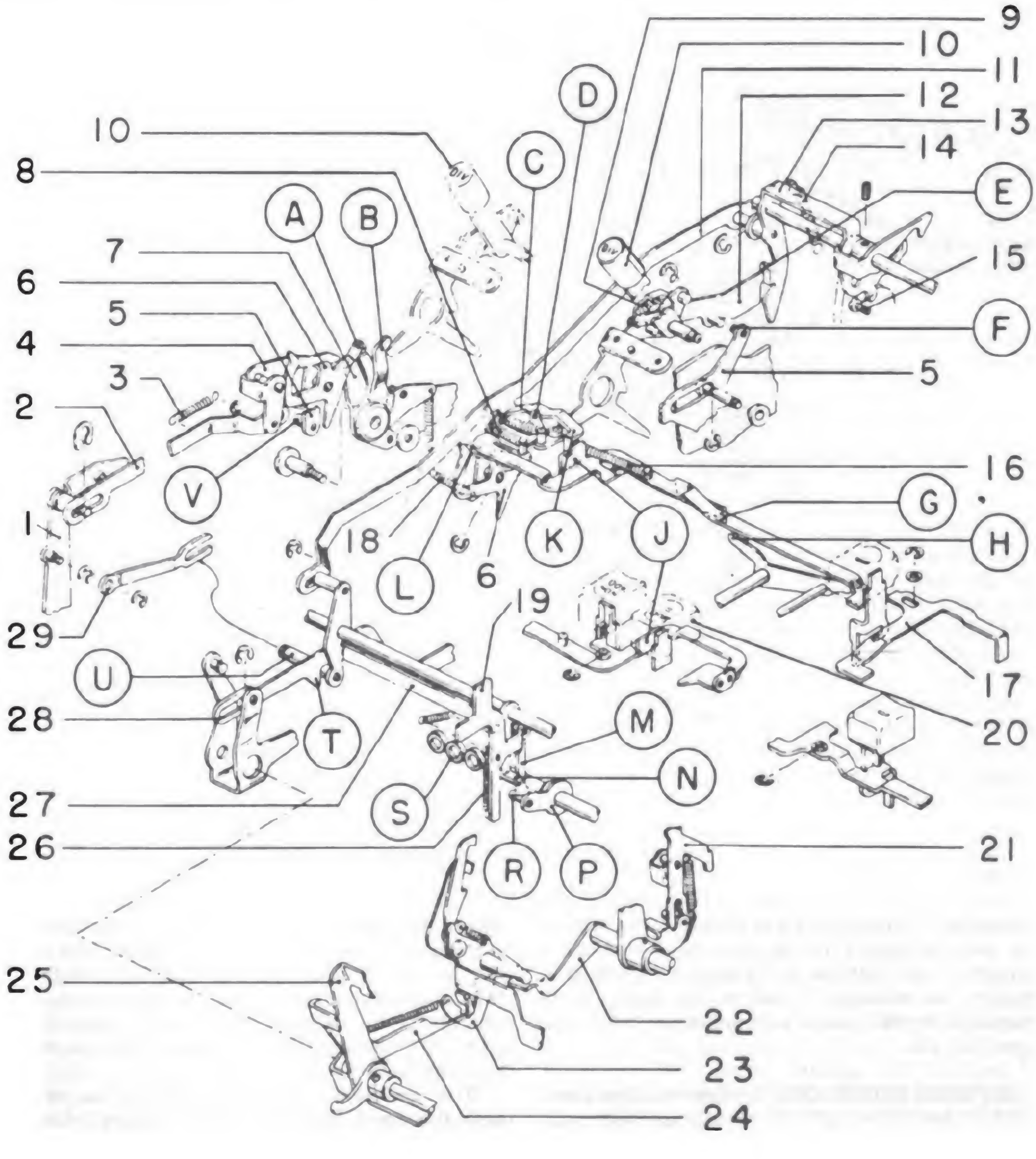

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Figure 14-16.—Interlocks.

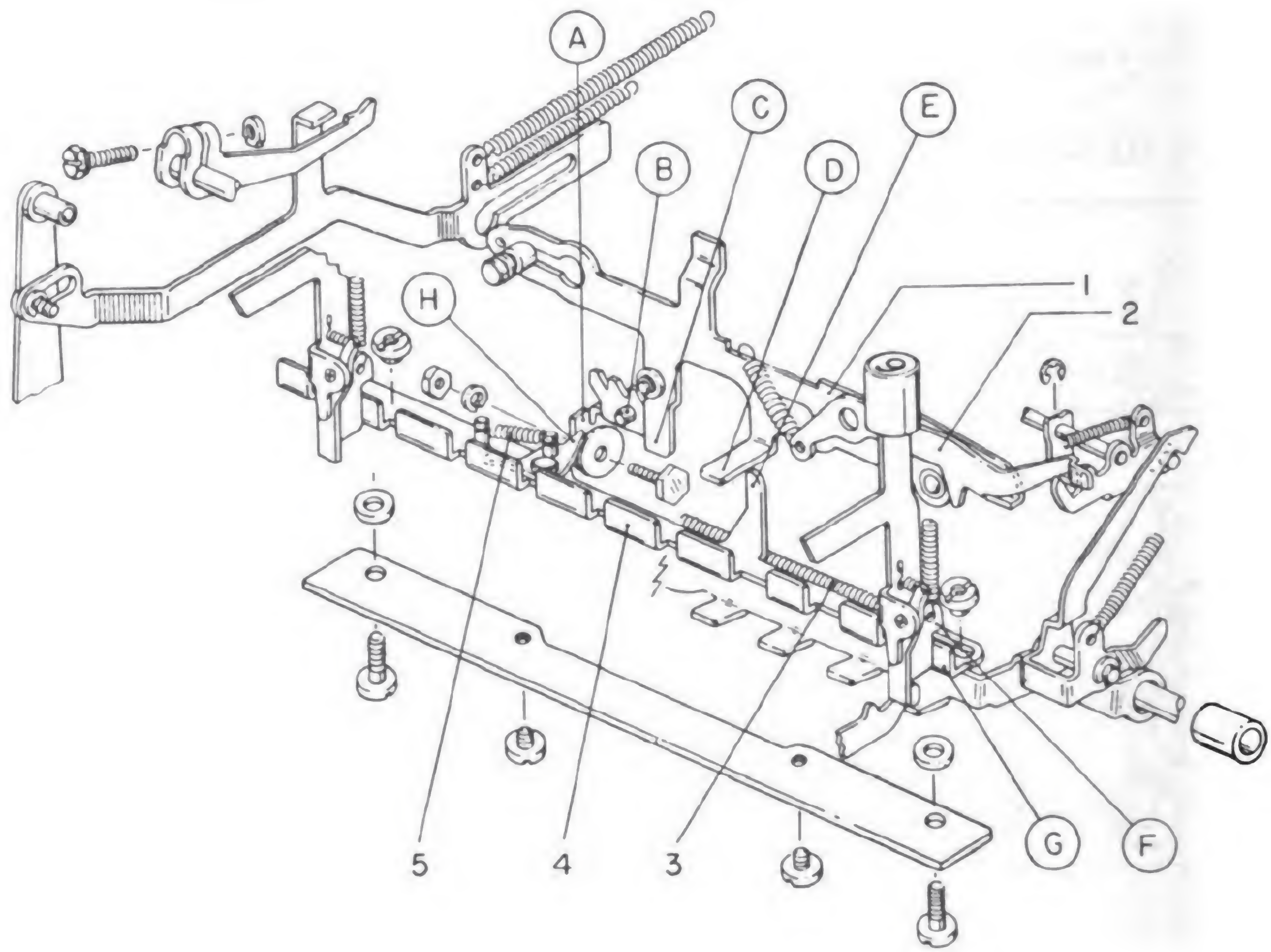

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Figure 14-17.—Interlocks (cont.).

numerals 1 through 29 and letters A through V are used in figure 14-16, and that numerals 1 through 5 and letters A through H are used to identify an enlarged view of the same parts identified by the same numerals and letters in figure 14-17.

DIVISION INTERLOCK.—When you depress a multiply key, the multiply non-print bellcrank (1, fig. 14-16) moves the division interlock arm latch link (2) rearward and raises the division interlock arm latch (4). The division interlock block arm (6) then moves under spring tension (18) to block the division control arm (7) by point (A's) dropping in front of point (B) to prevent depression of the division key (10). The upper extension of block arm (6) contacts extension (L) and positions the multiply and division keyboard interlock slide (17) to the right and causes extension (G) to move over extension (H) and block the universal bar. At the same time, slide (17) blocks the non-add key, the subtract key, and the total bar.

The division interlock remains in effect until the total operation takes place. As the total slide (5) moves to the rear, stud (V) contacts the lower extension of block arm (6) and moves the upper extension of (6) away from extension (L) to permit spring (16) to restore slide (17). Extension (A) also rises out of the path of extension (B). Block arm (6) is relatched with the interlock arm latch (4).

MULTIPLICATION INTERLOCK.—Depression of the division key (10) lowers the rear of the printing hammer catch block arm (12) below extension (E) of the printing hammer catch assembly (13), which then rotates as a result of tension provided by spring (14) until it limits against screw (15) to block the multiply hammer and release the division hammer, at the same time that it moves the multiply interlock bail operating link (11) forward. Extension (C) of link (11) then contacts extension (D) to position (through yield springs, 8) the multiply and division keyboard interlock slide (17) to the right, move extension (G) over extension (H) to block the universal bar, and to block also the non-add and subtract keys and the total bar.

The front end of link (11) rotates the multiply interlock bail (27) and causes extension (N) to move pawl (M) off stud (R) of arm (P) and permit the keystem interlock (19) to move down through spring (26) and spread rolls (S) to block the multiply keys.

This interlock remains in effect until the total operation is completed. As the total slide (5) moves to the rear, stud (F) contacts the lower extension of bail (13) and drives it rearward to permit block arm (12) to move back up to a blocking position through tension provided by spring (9). As bail (13) restores, the division hammer is blocked and the multiply hammer is released. When link (11) moves rearward, extension (C) releases extension (D) and permits slide (17) to restore and unlock the universal bar, the subtract and non-add keys, and the total bar. The front end of link (11) permits bail (27) to restore and pawl (M) moves over stud (R) while the main shaft is in the forward position. On the return stroke, stud (R) drives pawl (M) and interlock (19) out of blocking position of the multiply keys.

MAIN SHAFT INTERLOCK.—The multiply keys are blocked and cannot be depressed when the main shaft is out of its normal position by the keystem interlock (19). Normally, the keystem interlock is held in its upward positions in the following manner: Pawl (M) on the keystem interlock rests on stud (R) on the interlock arm (P) pinned to the universal drive shaft. As the main shaft turns forward, stud (R) moves down to permit keystem interlock (19) to move down under the tension of spring (26) and cause the front extension of the multiply keystem interlock to spread lock rollers (S) and prevent the operator from depressing a multiply key until the multiply keystem interlock is restored by stud (R), when the universal drive shaft restores to its normal position.

KEYSTEM INTERLOCK.—Depression of any multiply key blocks all other multiply keys through a series of rollers (S) in an enclosed channel. These stainless steel rollers have an accumulated clearance between them of just enough space for one multiply keystem to pass. With any multiply key depressed, the rollers therefore block all other multiply keys.

NON-ADD INTERLOCK.—To prevent multiplication and addition at the same time, lock the multiply keys when the non-add key is depressed. This is accomplished when extension (T) on the non-add link (28) contacts stud (U) of bail (27) to trip the keystem interlock (19) and lock the multiply keys.

0 TO 9 INTERLOCK.—If a multiply key is partially depressed, the reaction produced releases the multiply non-print bellcrank (1). The multiply interlock link (29) then rotates the multiply interlock bail (27) and causes extension (N) to move pawl (M) off stud (R), which permits the keystem interlock (19) to move down through spring (26) and spread rollers (S) to block the multiply keys 0 to 9 from the second depression. If the machine is mis-operated in this manner, pull the release key and depress the D key to clear the stop section and unlock the multiply keys.

MULT TOTAL KEY INTERLOCK.—The mult total key (21) is blocked from depression during a machine operation of a multiply key by the mult total interlock arm (24). When the mult key is depressed, keystem lock bail (25) moves to the rear to permit the mult total interlock arm (24) to latch with the negative mult cut-out arm (23) and prevent the space-over bellcrank shaft arm (22) from rotating and blocking the mult total key (21). On the last return stroke of the mult key operation, the keystem lock bail (25) is restored to unlatch the mult total interlock arm (24) from the negative mult cut-out arm (23). This action allows depression of the mult total key (21).

The mult total key (21) is blocked from depression when the machine is normal (or during listing operations) by extension (J) of the keyboard interlock slide (17) under the

mult total key button (20). When the multiply key is depressed, the keyboard interlock slide (17) is positioned to the right to move extension (J) out of blocking position of the mult total key button (20).

The mult total key (21) is also blocked from depression during division. This is accomplished by the moving of extension (K) (on the multiply interlock operating link (11) under the mult total key button (20) as the division key is depressed and the printing hammer catch block arm (13) rotates to move link (11) forward. On the total stroke, the total slide (5) restores block arm (13) to bring link (11) to the rear and move extension (K) out of blocking position of the mult total key button (20).

STOP SECTION INTERLOCK.—When the stop section is in its normal position, extension (A) (fig. 14-17) holds the multiply key lock slide (4) by means of yielding paw (H) beneath the multiply keystems to prevent their depression (between F and G in the illustration). As the multiplicand is entered in the stop section, the stop section moves to the left. Extension (A) then moves to the left to permit the multiply key lock slide to be pulled to the left under tension of spring (3) until extension (E) limits on extension (D) in order that the multiply keys may be depressed.

Yielding pawl (H) on the multiply key lock slide allows the stop section to restore to normal when a multiply key is latched down. When the multiply key restores, yielding spring (5) moves slide (4) beneath the multiply keys.

The function of stud (B) is to contact extension (C) and relatch slide (1) with latch (2) in case slide (1) and latch (2) are unlatched and the correction key is used, or the stop section is cleared under power.

Printing Control Mechanism

The printing control mechanism (Simpla-Tape) on the Model DM99 Remington calculator eliminates repeat printing by the divisor or the multiplicand. After the backspacer operates on the FIRST printing operation of a multiplication or division problem, the multiply and division non-print bail (3, fig. 14-18) is released and drops down on the front type rack guide comb to prevent additional printing until the stop section restores. This action eliminates repeat printing of all characters except M and Q on the tape, and the non-add character also when the 0 multiply key is used.

When the calculator is in its normal operating position, latch (4) holds the multiplier and division non-print bail (3) out of the path of the printing hammers for regular printing. During a regular multiplication or division operation, as arm (C) operates on the first backspacing, link (5) is lowered at the same time to pull latch (4) down and release it from lip (B) on bail (3). This movement permits bail (3) to drop through spring (13) to block the printing hammers. Bail (3) remains down until the stop section restores. Roller (D) on the reset gears contacts the forward extension of arm (9) to rotate it and raise link (10), and also to restore bail (3) through spring (12) so that latch (4) can relatch lip (B).

If the first multiplier is a short-cut multiplier, the machine backspaces on the first return stroke before a printing operation occurs. It is therefore necessary that bail (3) be prevented from dropping at this time, and this is accomplished by the moving up of latch (11) to block lip (B) of bail (3) as arm (E) of the printing hammer catch shaft is raised on the first return stroke. At the same time, arm (C) and link (5) lower latch (4) to permit lip (B) to latch with latch (11). After printing occurs on the last return stroke of this operation, as the machine backspaces and the printing hammer catch shaft restores, arm (E) lowers latch (11) to permit bail (3) to drop down and remain in that position until the stop section restores.

NOTE: Unhook spring (13) from hole (A) and hook it to hole (F) to make the multiply and division non-print bail (3) inoperative when you service the machine.

The backspace drive arm (11, fig. 14-7) is made in two parts, to prevent manual use of the backspace slide from causing latch (4) to release bail (3) and block the hammers. The short backspace drive arm (11, fig. 14-7) is clamped to the shaft; and when operated, it picks up the stud in the long backspace drive arm to operate the backspace pawl and stop section in a normal manner. The manual backspace slide operates only the long backspace drive arm.

Repeat Shaft Arm Latch

The repeat shaft arm latch on the Model DM99 calculator prevents premature restoration

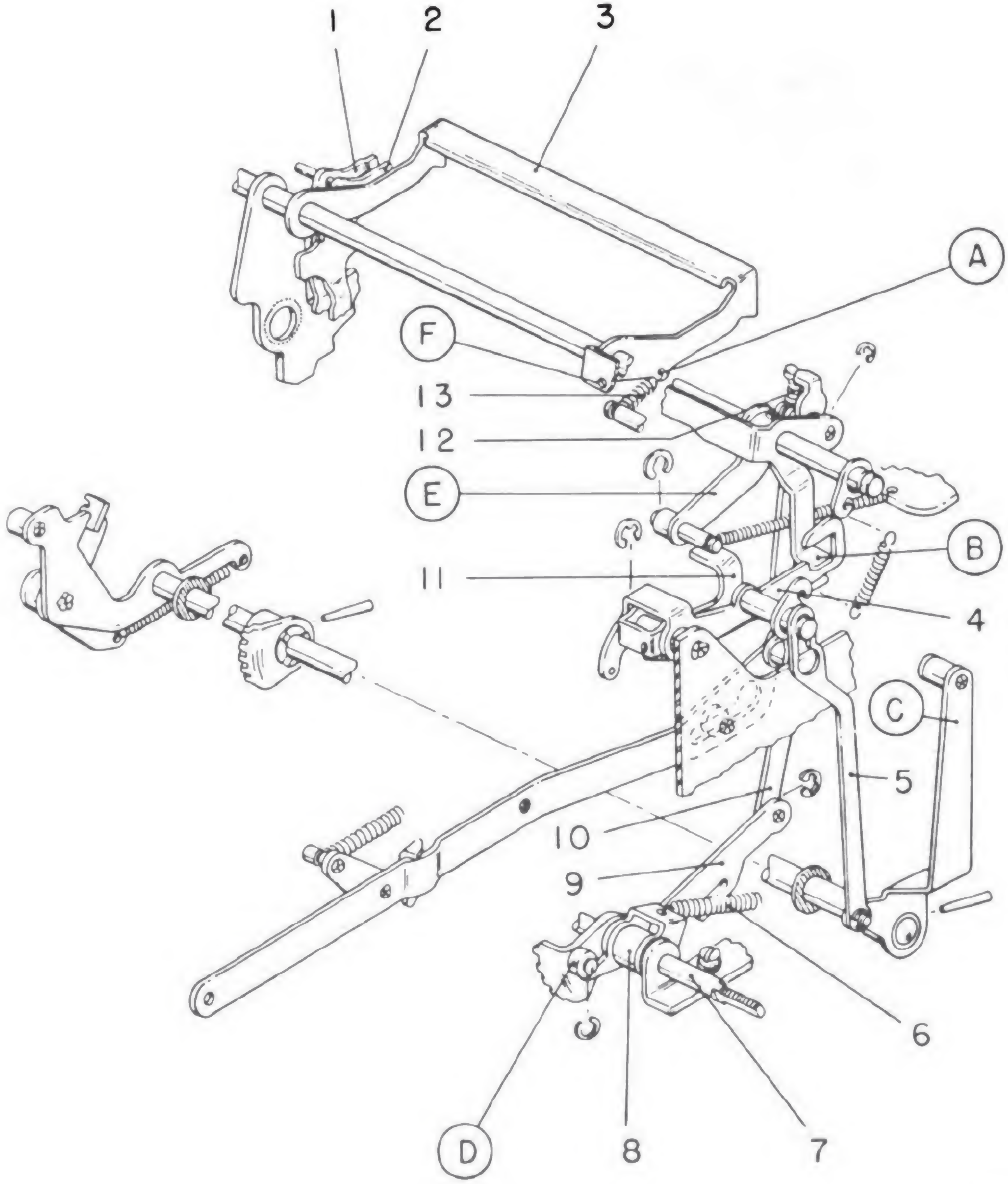

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Figure 14-18.—Printing control mechanism.

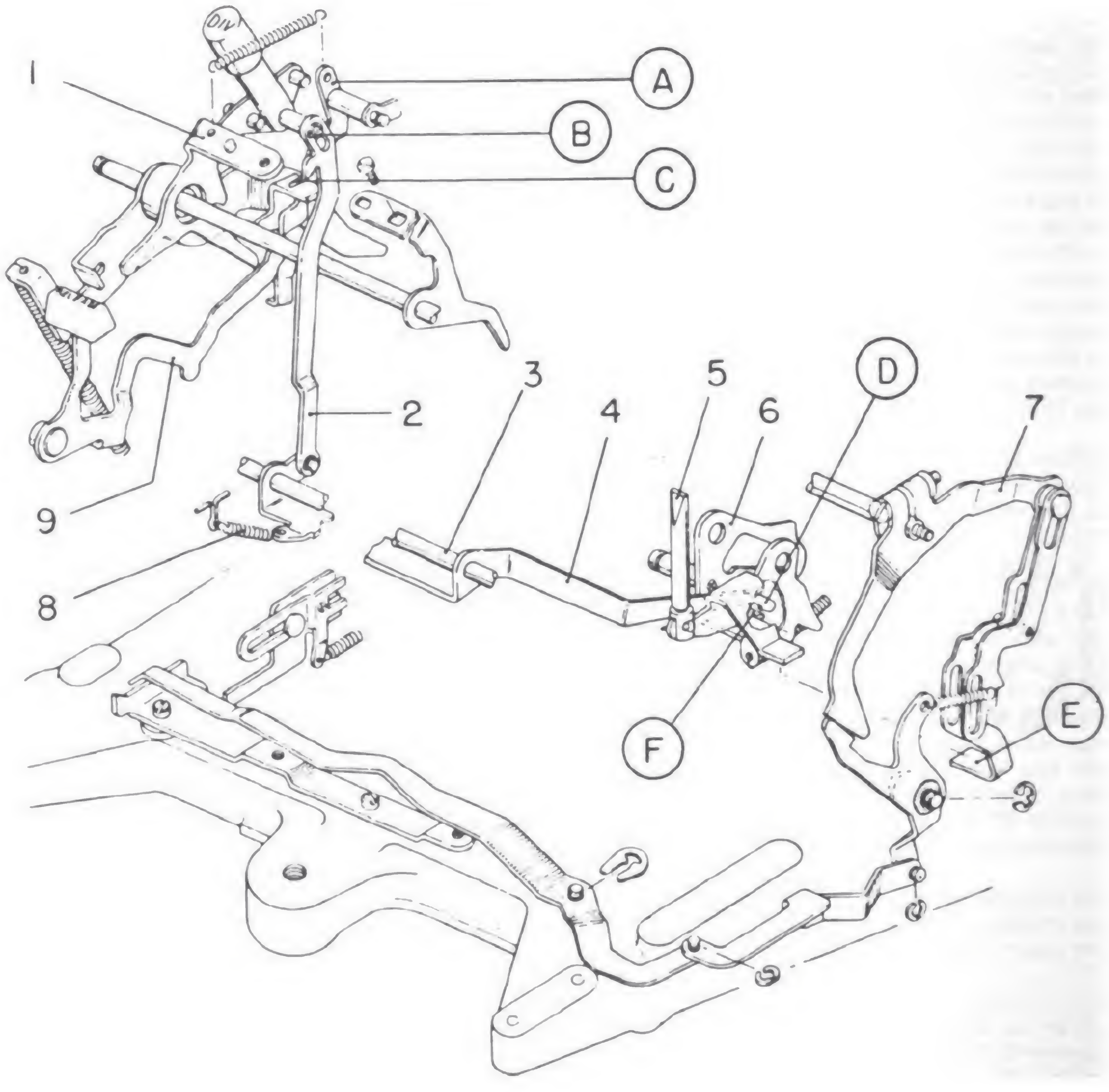

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Figure 14-19.—Repeat shaft arm latch.

of the stop section during division. This mechanism consists of a latch operating link (2, fig. 14-19) secured to stud (B) in division key (1), and it has an extension (C) which rests just above latch (A), riveted to the left side frame. The other end of the latch operating link (2) is connected to the repeat shaft arm latch (4), which pivots on the feature key latch shaft (3). The latching extension (D) of the repeat shaft arm latch (4) normally rests above the rear edge (F) of the repeat shaft arm (6).

When the division key (1) is depressed, stud (B) lowers link (2) to permit bail (4) to rotate on the feature key latch shaft (3), under tension

of spring (8). The lower extension (D) of the repeat shaft arm latch (4) over latches lip (F) of the repeat shaft arm (6) as soon as the inner link (E) on the right division shaft arm (7) raises the repeat shaft arm (6).

When division key (1) restores, stud (B) raises link (2), which (in turn) rotates the repeat shaft arm latch (4) upward and unlatches extension (D) from lip (F). This action permits the plunger (5) to drop, and it also allows the stop section restoring link to restore the stop section to the normal position on the add-back stroke.

Operation of the release key during division actuates latch (A), through the release key extension (9). Latch (A) contacts lip (C) to lift link (2) to normalize the repeat shaft arm latch (4), thereby unlatching the repeat shaft arm (6). The repeat shaft arm (6) is then free to restore when the right division shaft arm (7) is unlatched to lower inner link (E).

Type Rack Lock Bail

The function of the type rack lock bail (1, fig. 14-20) is to prevent the type racks (3) from falling from the machine in cases the machine is turned upside down when it is in the CARRY position. It also prevents the type racks (3) from rebounding when they restore, particularly during such fast operations as multiplication and division.

The last three teeth at the rear of the adding racks were removed so that the adding racks could disengage from the operating gears of the type rack during carrying operations. This removal of the teeth was necessary because of the increased capacity of the machine, necessitating a faster carry. Disengagement of the adding racks from the operating gears of the type rack eliminates dragging of the type racks and the type rack operating gears.

When the machine is normal, stud (F) in the type rack lock bail (1) is held in an over-latched position with latch (9) by roller (D) on the main shaft. Extensions (A) of the type rack lock bail (1) are over the studs (B) of the type racks (3).

As the main shaft operates, roller (D) releases extension (C) of the type rack lock bail (1) and, at this time, stud (F) latches with latch (9). Stud (E) contacts the type rack lock bail latch (9) to unlatch the type rack lock bail (1), and spring (7) rotates the bail clockwise out of the path of the type racks (3). As the main shaft restores, roller (D) contacts extension (C) to bring the type rack lock bail fingers (A) down over the studs (B) in the type racks (3) to position latch (9) over stud (F). The function of this latch is to delay the release of bail (1) to permit the accumulator racks to remesh with the type rack operating gears when they come out of the carry position.

The type racks (3) may be removed from the machine by placing all racks in the CARRY position, inserting a ONE and ALL spaces in the STOP section, and turning the main shaft forward to permit the type racks (3) to pass the lock bail. The type racks (3) may then be lifted out of the machine, with the exception of the last two on the left. You can remove these by pushing the accumulator racks forward into the carry position. To remove the character rack, loosen the rear type rack guide comb.

Positive Rack Restoring Mechanism

The positive rack restoring mechanism (fig. 14-21) restores the accumulator racks from the carry position when the accumulator rack heels limit against the space stops.

As the main shaft moves forward, its drive plate (1) contacts roller (2) to actuate the rack restoring actuator bellcrank (3), which then moves the rack restoring actuator link (4) to the rear until lip (B) limits against stud (A) in the side frame. As link (4) moves to the rear, the rack restoring actuator assembly (5) operates to move the rack restoring plate (6) to the rear, where it contacts the upright portion of the accumulator racks to push them to the rear so that the carry racks may restore. On the return stroke, all parts are restored to their normal positions by the tension provided by spring (7).

The positive rack restoring mechanism in a Model DM99 Remington calculator has HIGH speed. Its low speed is 150 strokes per minute, and its high speed is 190 strokes per minute. Calculators with this type of restoring mechanism have .015 inch ground off the faces of their ciper stop in order to obtain proper lug clearance, because the accumulator rack slides do NOT engage the scatter lugs when they are in the zero position.

Non-add and Subtotal Mechanism

The subtotal key on a Model DM99 calculator may be latched down any time. If it is latched

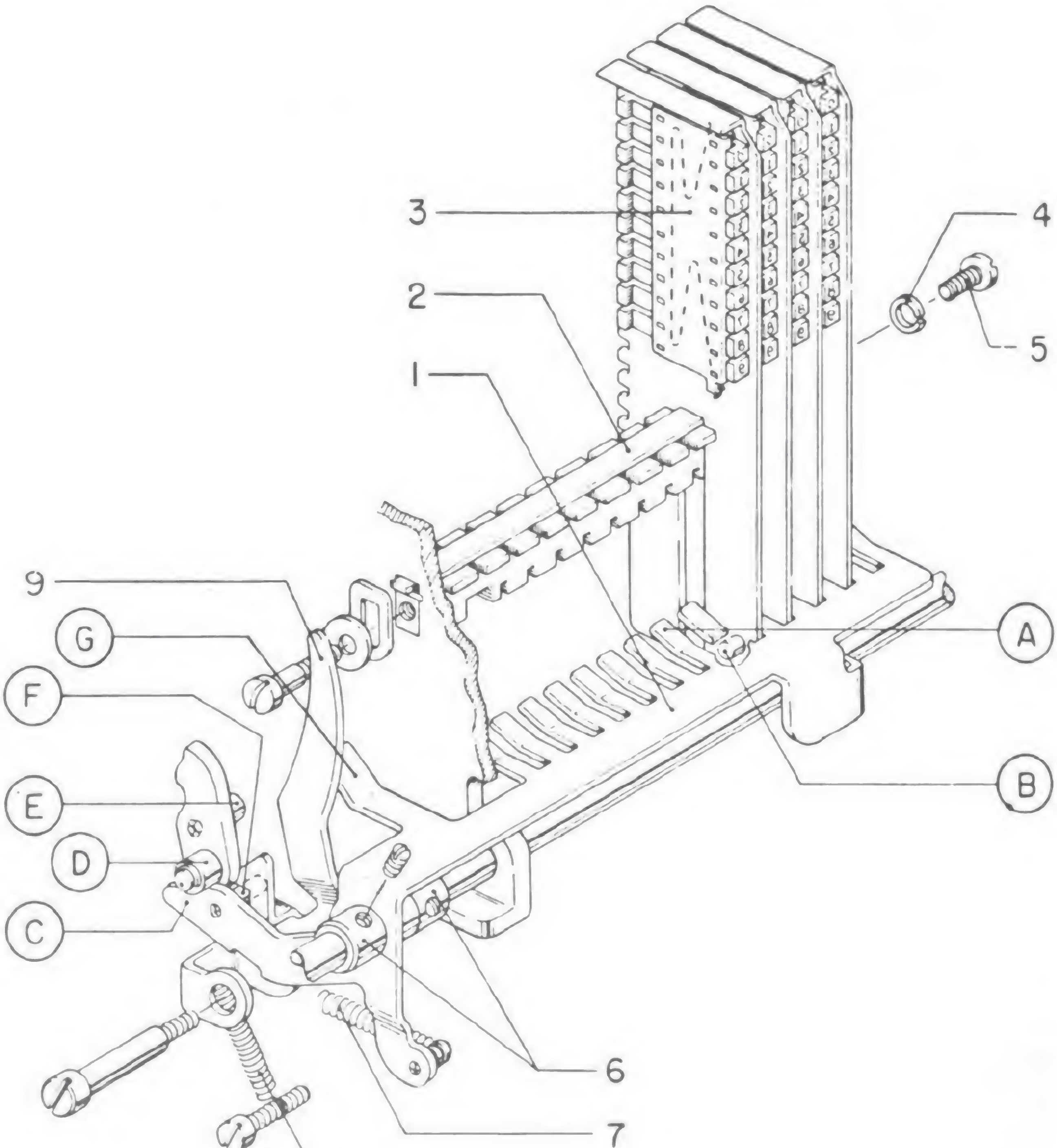

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Figure 14-20.—Type rack lock bail.

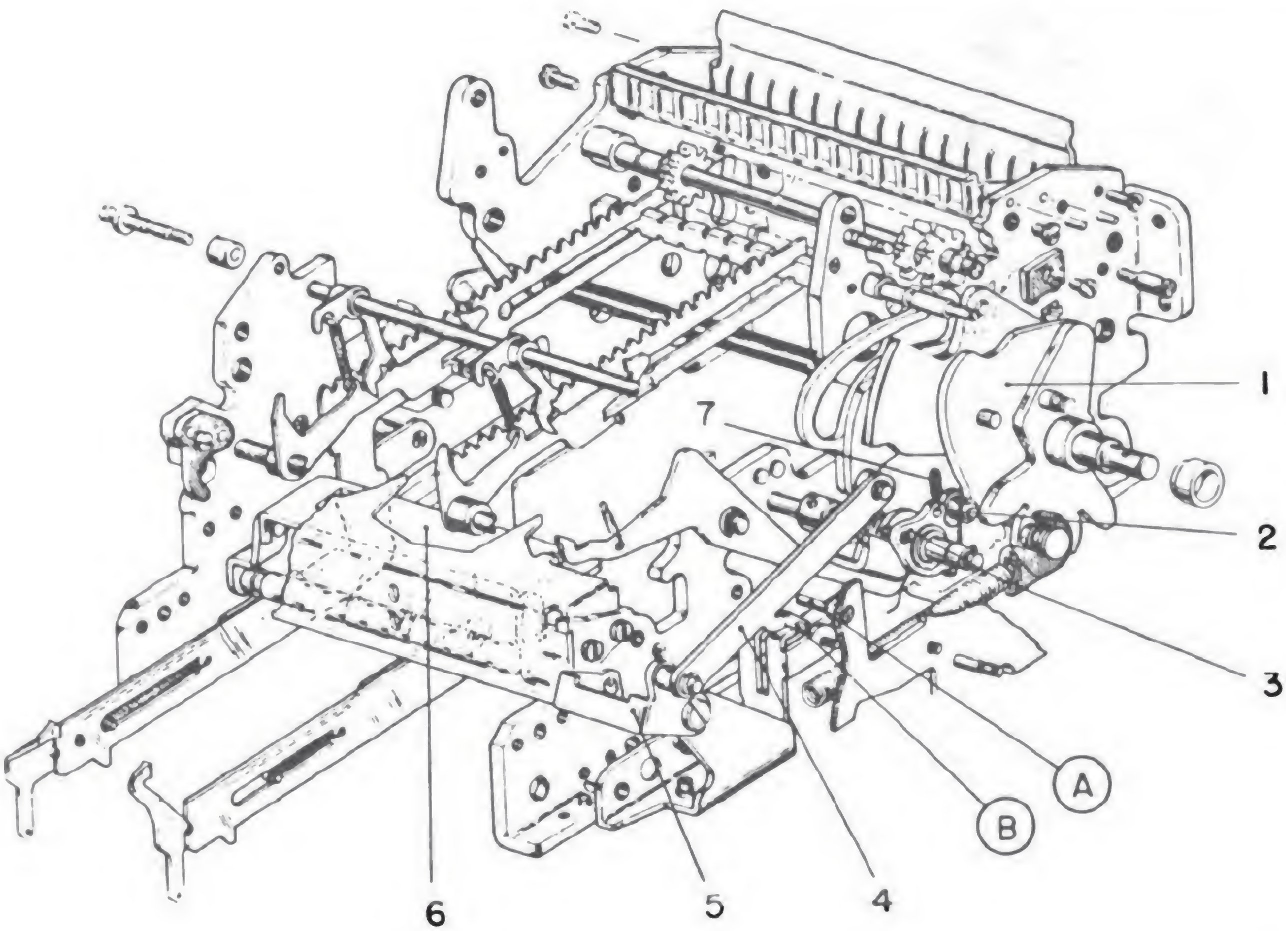

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Figure 14-21.—Positive rack restoring mechanism.

down during multiplication, the machine takes an automatic blank stroke and the subtotal at the end of the problem.

When you depress the subtotal key, (3, fig. 14-22), the subtotal bellcrank (1) raises the non-add and subtotal link (8) to position yielding pawl (E) in the path of roller (D) on the total slide (6). As the total slide (6) moves to the rear, roller (D) contacts yielding pawl (E) and positions the non-add cam lock lever stud (L) behind the total cam. At the same time, the rear part of yielding pawl (E) contacts stud (F) and positions the character selector shaft for the S symbol in the printing position. When the machine is in its normal position, pawl (B) rests on top of lip (C). As the total slide (6) moves rearward, pawl (B) drops back of lip (C) of the subtotal key latch (4). As the total slide (6) restores, pawl (B) pushes lip (C) forward and unlatches the subtotal key.

Depression of the non-add key (2) rotates the non-add bellcrank (5). Roller (7) contacts lip (A) of the non-add and subtotal link assembly (8) and positions the non-add cam lock lever assembly (9) to the rear of the total cam, and at the same time it positions the character selector shaft for the V symbol in printing position.

On calculators which have latch-down subtotal mechanisms, the inside flange of the total cam is shorter, so that the non-add cam lock lever assembly (9) can be positioned later, as is the case when it is driven to the rear by the total slide.

The purpose of extension (G) on the total slide (6) is to block stud (H) on the left character shaft, so that the character stop will not overthrow during subtotal operations.

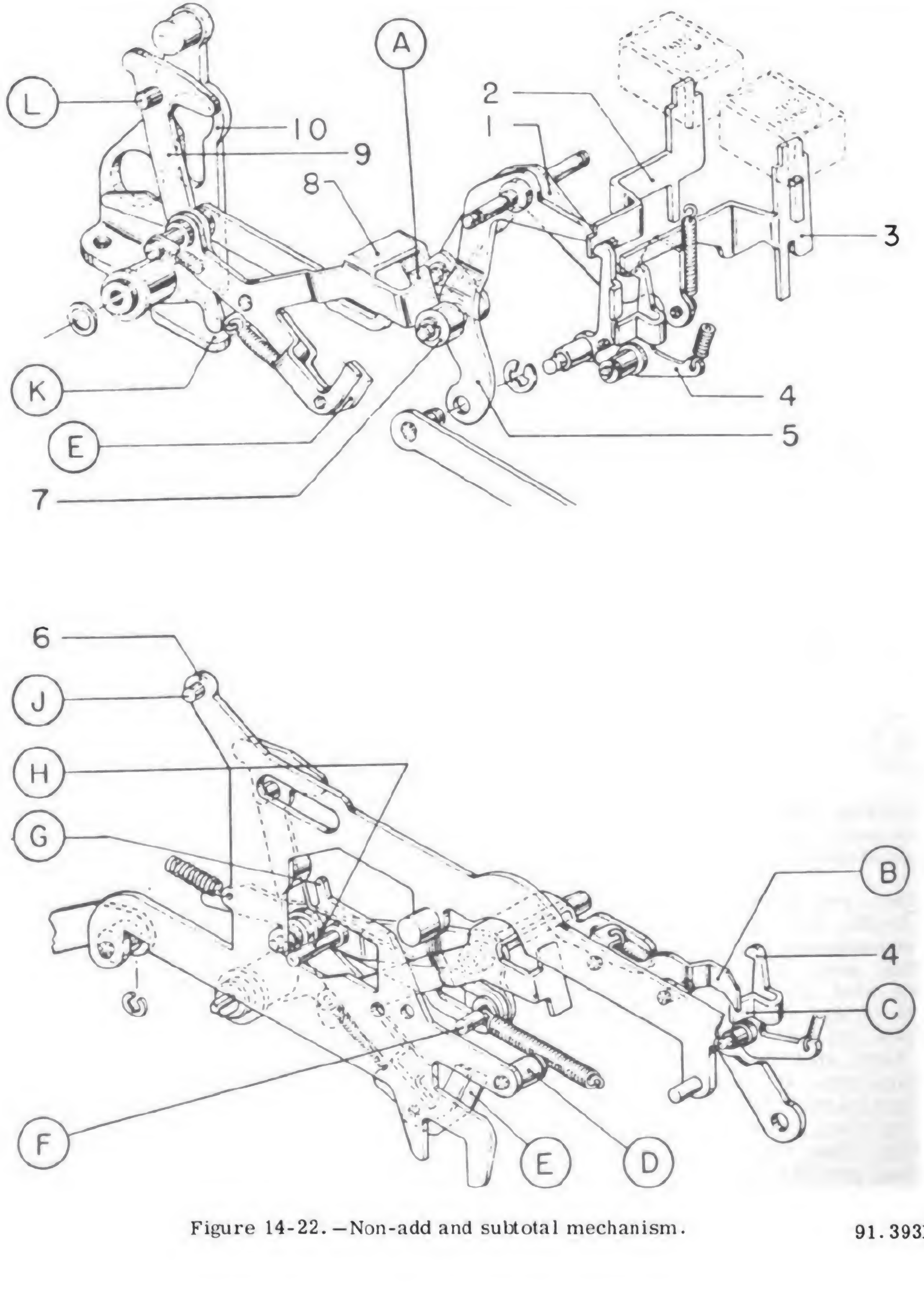

Figure 14-22. —Non-add and subtotal mechanism.

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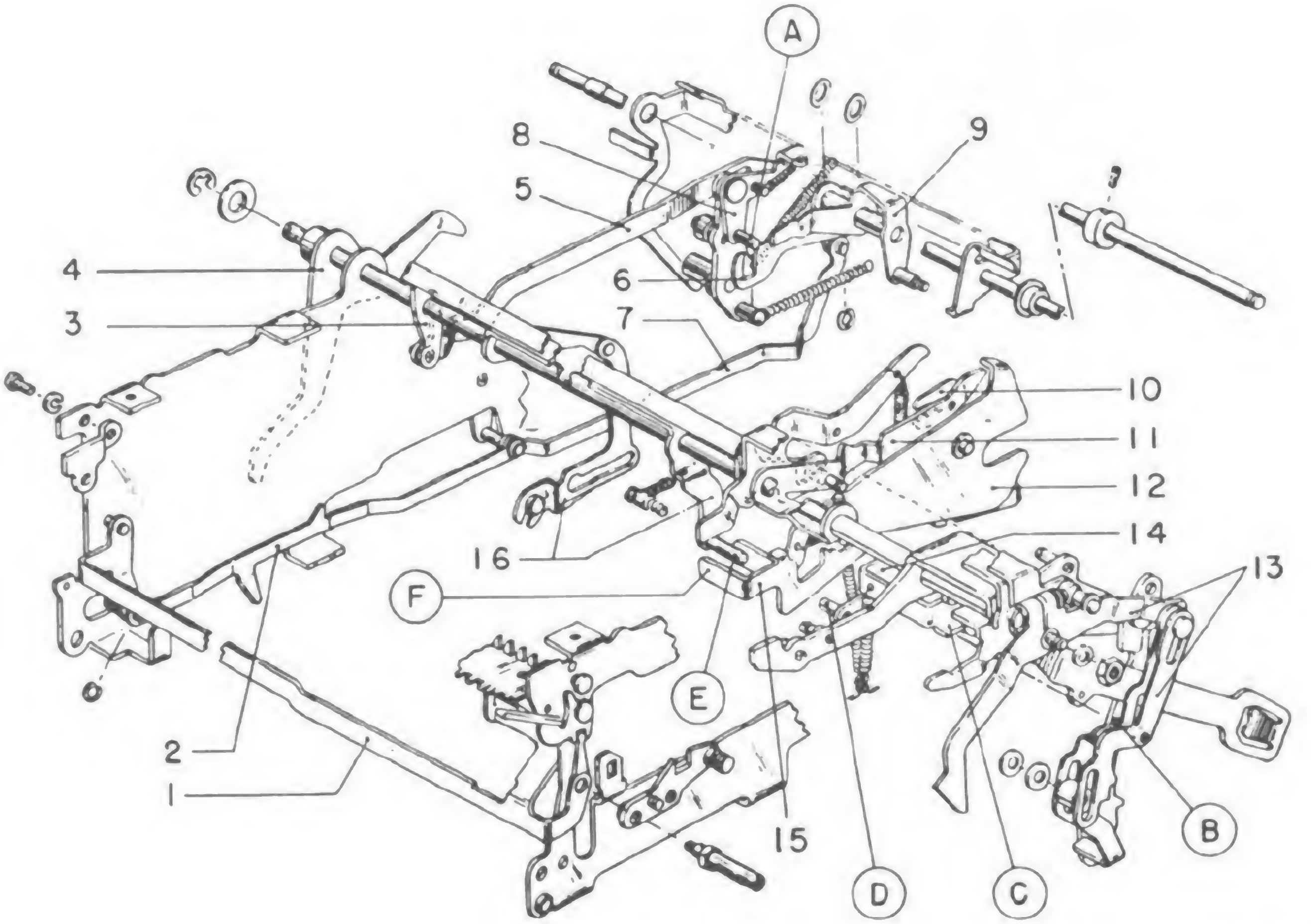

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Figure 14-23.—Credit balance mechanism.

Credit Balance Mechanism

The credit balance mechanism in a Model DM99 calculator is shown in figures 14-23 and 14-24. Numerals 1 through 16 and letters A through F are used to identify parts in figure 14-23, and numerals 17 through 27 and letters G through M are used to identify parts in figure 14-24.

The following portion of the discussion of the credit balance mechanism is for POSITIVE TO NEGATIVE OPERATION.

If you enter an item in the stop section and depress the subtract key, the credit balance mechanism operates. As you enter the item, the blank stroke lock bellcrank (1, fig. 14-23) rotates and pulls links (2) and (7) to the front to the machine to position the outer negative total block arm (6) to block stud (A) in the negative total link operating arm pawl (8).

As the main shaft moves forward, the subtract slide (12, fig. 14-24) moves to the rear and extension (F) of the subract slide pivot pawl (15) contacts stud (E) of the credit balance bellcrank pawl lift arm (16). The left extension of this lift arm (16) then raises the bellcrank pawl (N) to position its upper extension (H) beyond the upper stud (G) of the credit balance operating bellcrank (17).

When a complete carry-over occurs and the credit balance and motor control slide (18) moves to the front of the machine to the carry position, it causes the bellcrank pawl (11) (secured to it) to rotate the credit balance operating bellcrank (17) counterclockwise. This action rotates the credit balance carry pawl cam assembly (19) to the rear and causes its

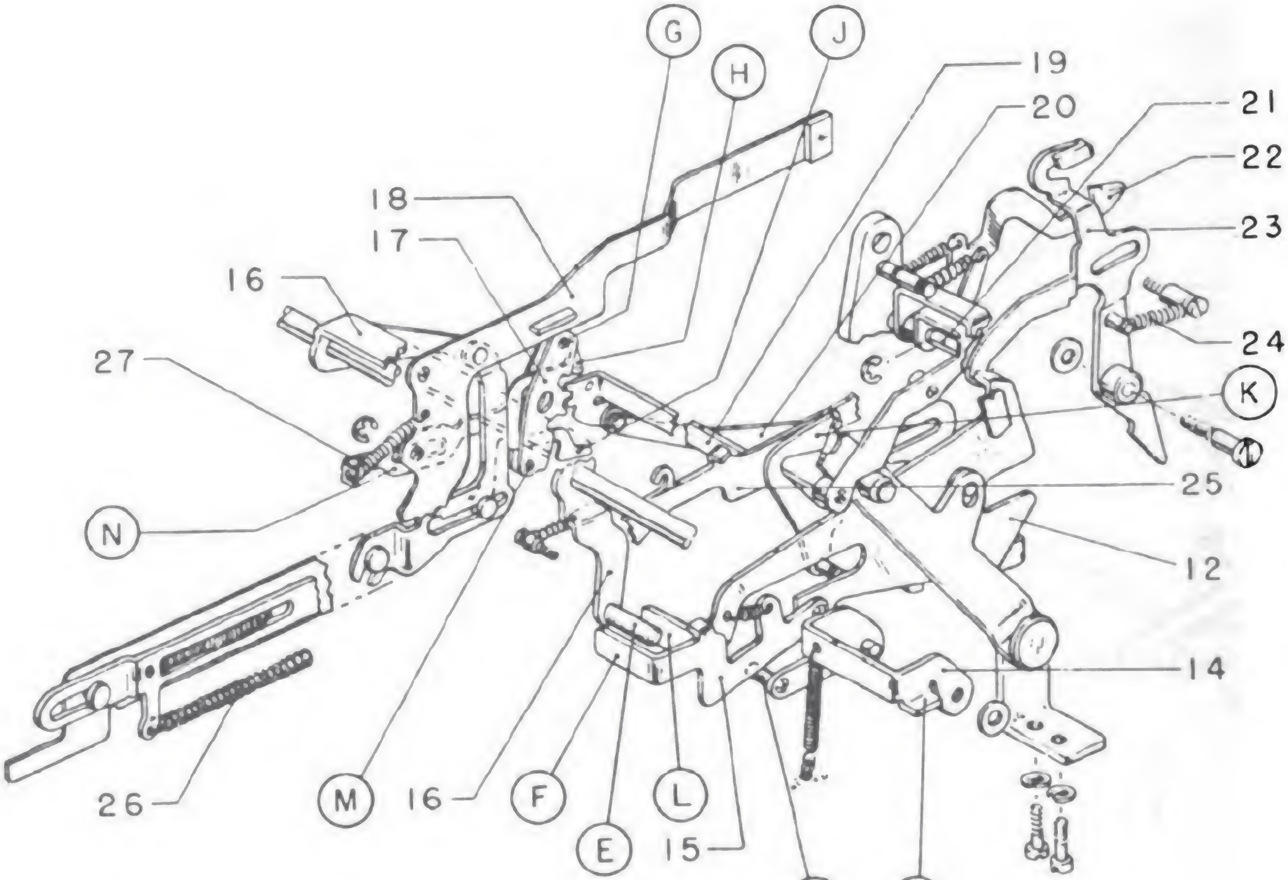

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Figure 14-24.—Credit balance mechanism—Continued.

right arm (K) to cam down the first carry pawl (25) to accumulate AUTOMATIC ONE. As the cam assembly (19) rotates, the negative total block arm link connected to it (20) moves to the front of the machine and causes the inner negative total block arm (9) to move up out of the path of stud (A) (fig. 14-23) on the negative total link operating arm pawl (8).

As the stop section restores, the blank stroke lock bellcrank (1) causes links (2) and (7) to move rearward to lower the outer negative total block arm (6) out of the path of stud (A) on the negative total link operating arm pawl (8). At this time, the machine is in a negative position, indicating that more has been subtracted from the machine than was added.

The following discussion of the credit balance mechanism is for NEGATIVE TO POSITIVE OPERATION.

In order to bring the machine from negative to positive position, it is necessary that you add a larger item than was subtracted. As you enter this item in the stop section, the blank stroke lock bellcrank (11) rotates to move links (2) and (7) to the front and position the outer negative total block arm (6) in the path of stud (A) on the negative total link operating arm pawl (8). This movement prevents the pawl from operating the subtract mechanism and permits the accumulator wheels to revolve back to the add position.

When the subtract slide (12) moves forward, extension (I, fig. 14-24) of this slide contacts

stud (E) and moves it to the front to cause the credit balance bellcrank pawl lift arm (16) to lower bellcrank pawl (N) so that its lower extension (J) is in position to hook over stud (M) of the credit balance bellcrank (17).

As a complete carry-over occurs in the add wheels and the credit balance and motor control slide (18) moves forward into carry position, the credit balance bellcrank pawl (N) rotates the credit balance operating bellcrank (17) clockwise. This action causes the credit balance carry pawl cam assembly (19) to rotate to the front of the machine, and also causes extension (K) to cam down the first carry pawl (25) to accumulate AUTOMATIC ONE.

When the cam assembly (19) rotates, it moves the negative total block arm link (20, fig. 14-24) rearward to lower the inner negative total block arm (9, fig. 14-23) into the path of stud (A) on the negative total link operating arm pawl assembly (8). As the stop section restores, the blank stroke lock bellcrank (1) pushes links (2) and (7) to the rear to lower the negative total block (outer) (6) out of the path of stud (A) on the negative total link operating arm pawl assembly (8).

The following discussion of the credit balance mechanism of a Model DM99 calculator pertains to CREDIT BALANCE DISCONNECT.

When the division key is depressed and the division shaft (4, fig. 14-23) rotates the right division shaft arm (13) counterclockwise, stud (B) on the outer link of the right division shaft arm (13) contacts lip (C) of the division subtract pawl to raise bellcrank (14) and cause it to move up. Stud (D) of bellcrank (14) contacts the subtract slide pawl (15) of the subtract slide (12) to raise extension (F) out of the path of stud (E) of the credit balance bellcrank pawl lift arm (16). During division operations, therefore, the credit balance mechanism is inoperative.

The function of yield spring (27) (fig. 14-24) on the credit balance bellcrank pawl (N) is to permit the credit balance and motor control slide (18) to move to the rear under the M & Q rack when an error occurs during division. Spring (26) of the credit balance and motor control slide (18) causes spring (27) to yield when the credit balance bellcrank pawl (N) limits against the credit balance operating bellcrank pivot stud (17). Slide (18) then moves to the rear under the M & Q rack to cam its own carry pawl down and restore the division key. The machine then proceeds to clear out in the usual manner and stop.

Center Support

Because of the large capacity of the Model DM99 Remington calculator, a support plate (16, fig. 14-25) was added between the two center frames. The plate is anchored at the rear and at the front with screws (8) (15), and it supports the accumulator rack spring shaft (7), the hammer pivot shaft (5), the hammer latch shaft (3), the carry pawl latch shaft (1), and the carry pawl shaft (18).

MAINTENANCE AND REPAIR

Refer to the manufacturer's technical manual for the Model DM99 Remington calculator to get information concerning assembly and disassembly. The procedure for doing this is similar to the procedure given for disassemblying and reassemblying other office machines, but it is also different because the parts and mechanisms are different.

Inspect all parts as you disassemble the machine, and safeguard those you intend to reuse.

Cleaning Procedure

Use a cleaning machine for cleaning all parts which fit in the cleaning baskets. Keep small and large parts separate. CAUTION: Handle parts with care. Use an approved cleaning solution, and the same procedure as that outlined previously for cleaning other instrument parts.

When you finish the cleaning process, reinspect all parts for defects or damage you may have missed when you inspected them during disassembly. Be particularly careful when you inspect small parts.

Repairs

When you repair a calculator, follow the general rule previously given for the repair of office machines: DISCARD AND REPLACE ANY PART WHICH MAY ADVERSELY AFFECT THE OPERATION OF THE MACHINE.

Follow repair and adjustment instructions outlined in the manufacturer's technical manual for the calculator. The adjustment procedure, in particular, is very good. Space in this chapter does not permit a detailed discussion of the adjustment procedure.

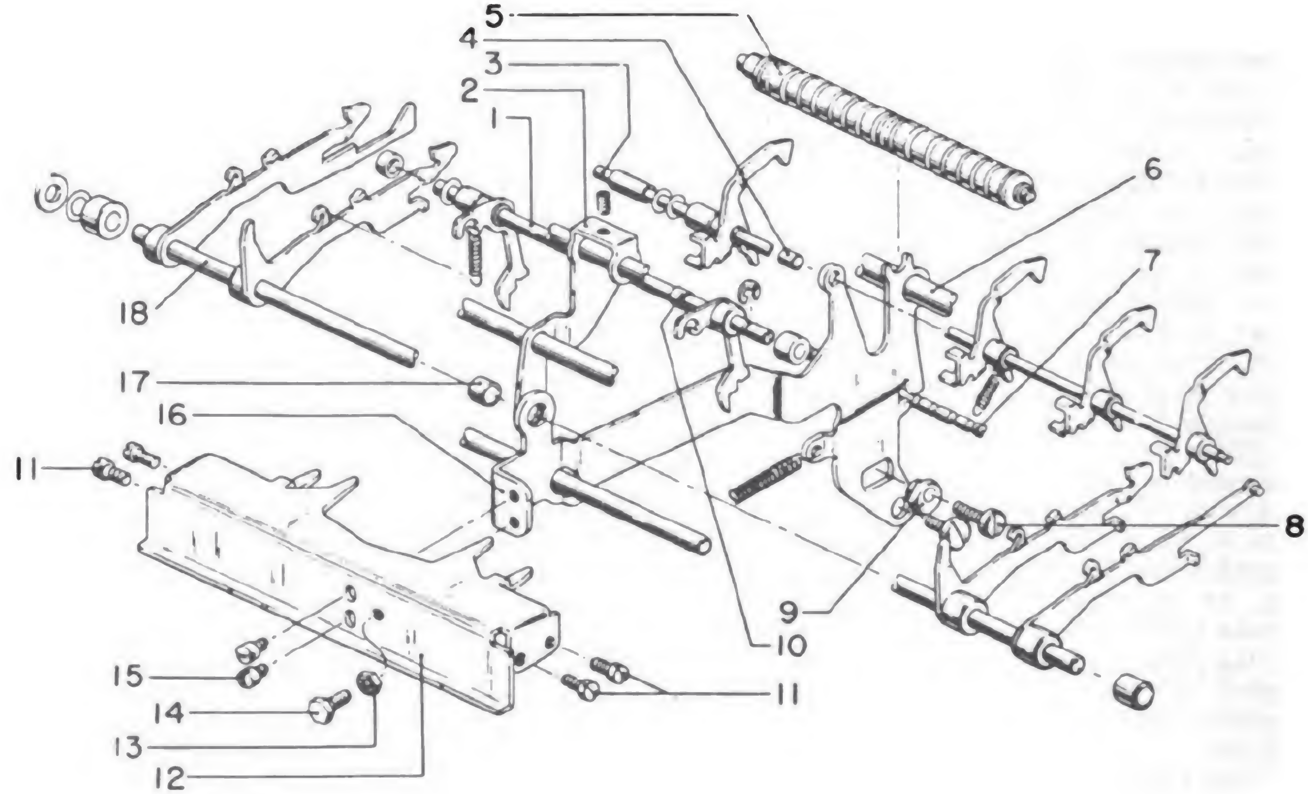

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Figure 14-25.-Center support.

CHAPTER 15

CASH REGISTERS

Before you can qualify for advancement in rating to an Instrumentman 1, you must know how to "disassemble, clean, reassemble, and make minor adjustments to cash registers." To qualify as a Chief Instrumentman, you must be able to "analyze and remedy casualties to cash registers."

Information presented on cash registers in this chapter will aid you in meeting the requirements for advancement in rating. Complete discussion of all cash registers in use, however, is beyond the scope of this training course. Two makes of cash registers have been selected for consideration, with some detail provided on one only. Refer to the manufacturer's technical manual for a particular model to learn about the operation, maintenance, and repair of the machine.

BURROUGHS CASH REGISTERS

You learned previously in this training manual that several Series P Burroughs adding machines can be converted to cash registers. The one illustrated in figure 15-1 is an example.

If a Burroughs P100 adding machine is mounted on a cash drawer and equipped with a paper rewind device, it makes a good general purpose cash register. The Burroughs P300 machine is also used extensively, in modified form, for cash registering. When a cash drawer(s) is added, by using both totals, the machine provides individual sales totals during a specified period and a gross total of sales at the end of the period.

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Figure 15-1.—Burroughs cash register.

NATIONAL CASH REGISTERS

The Model (Class) 21 National cash register is used in considerable numbers on naval ships; and for this reason, it is discussed as a representative type in this chapter. Figure 15-2 shows a Class 21 National cash register, with some of the nomenclature listed.

Illustrations of various mechanisms of the machine are shown when they are discussed. You can learn much about many of them at this time, however, by studying illustrations 15-3 through 15-12. Note that the part numbers are given with the nomenclature. Reference is made to some of these illustrations during the discussion.

The Class 21 National cash register, also called the receipt printer, has one row of transaction control keys in ROW 2 and five rows of AMOUNT keys. It is also constructed with clerks' keys in ROW 9, or with printing keys in ROWS 1 and 9.

This machine has ONE accumulating total and an itemizing feature. The items are accumulated on one set of counter pinions and

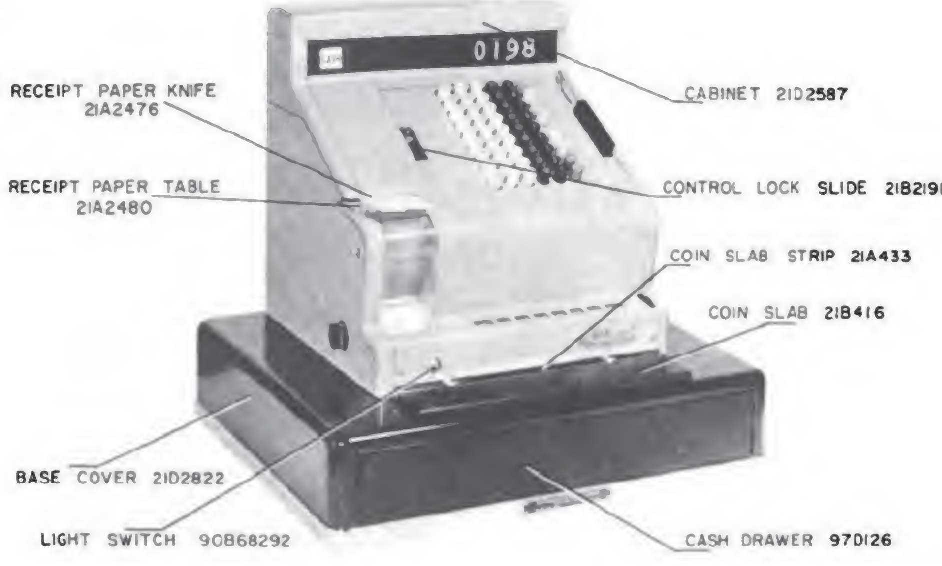

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Figure 15-2.—Class 21 National cash register.

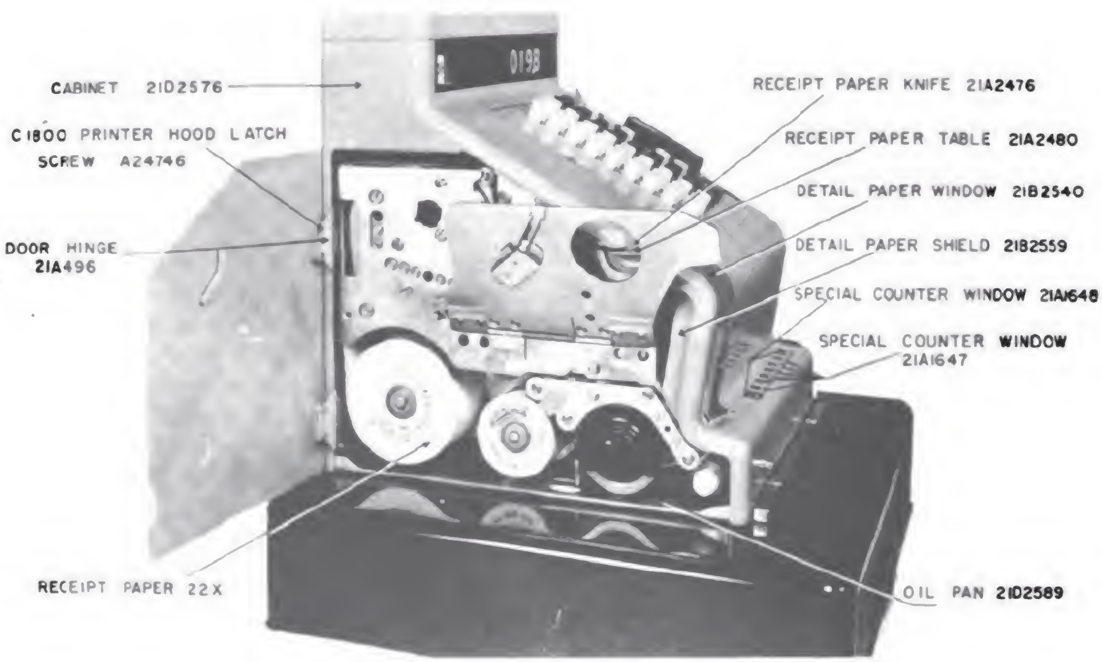

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Figure 15-3.—Nomenclature of a Class 21 National cash register.

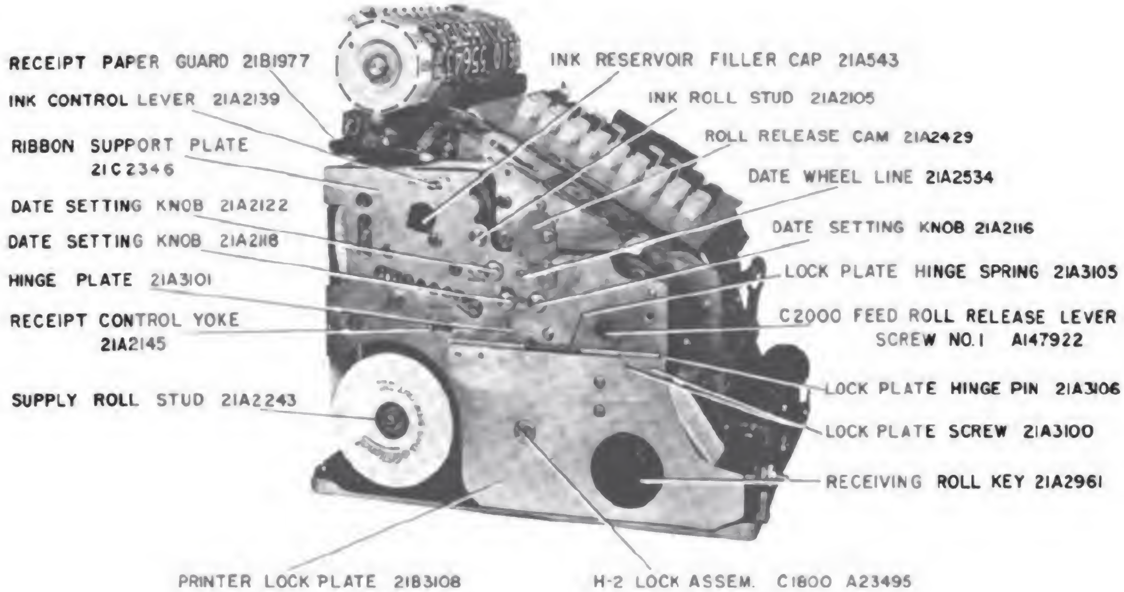

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Figure 15-4.—Nomenclature of a Class 21 National cash register—Continued.

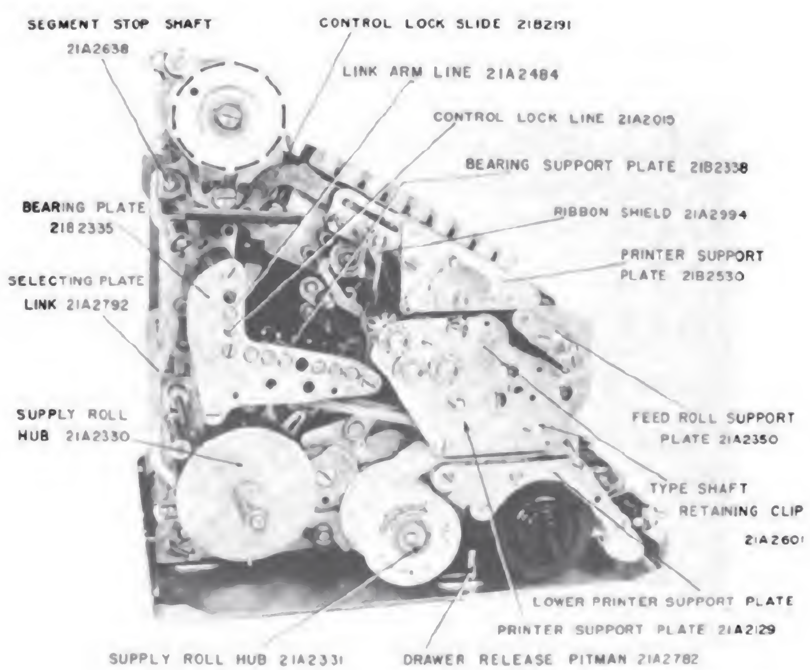

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Figure 15-5.—Nomenclature of a Class 21 National cash register—Continued.

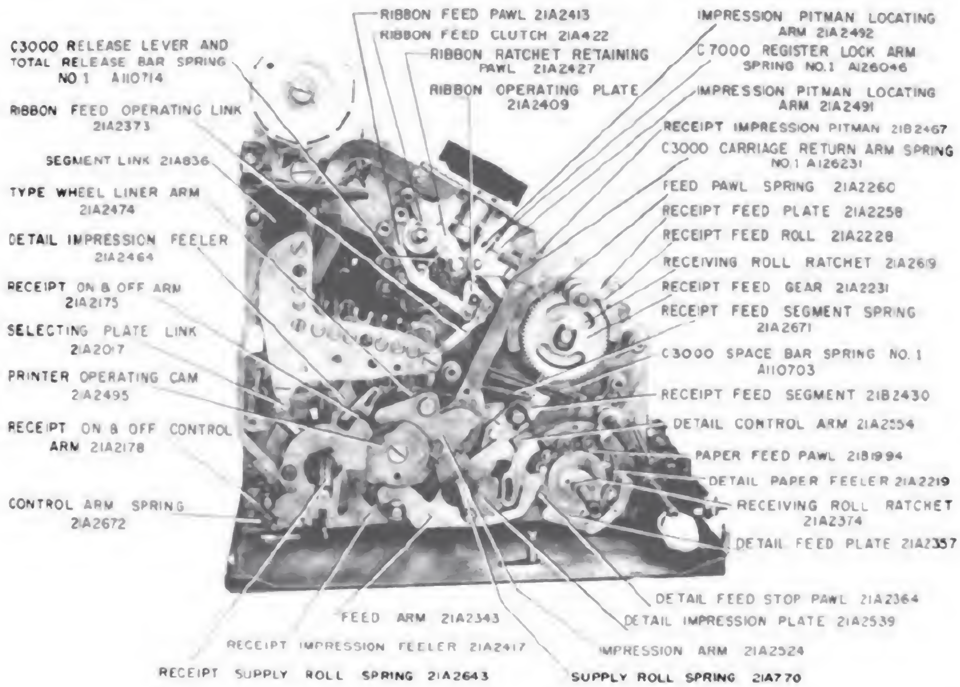

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Figure 15-6.—Nomenclature of a Class 21 National cash register—Continued.

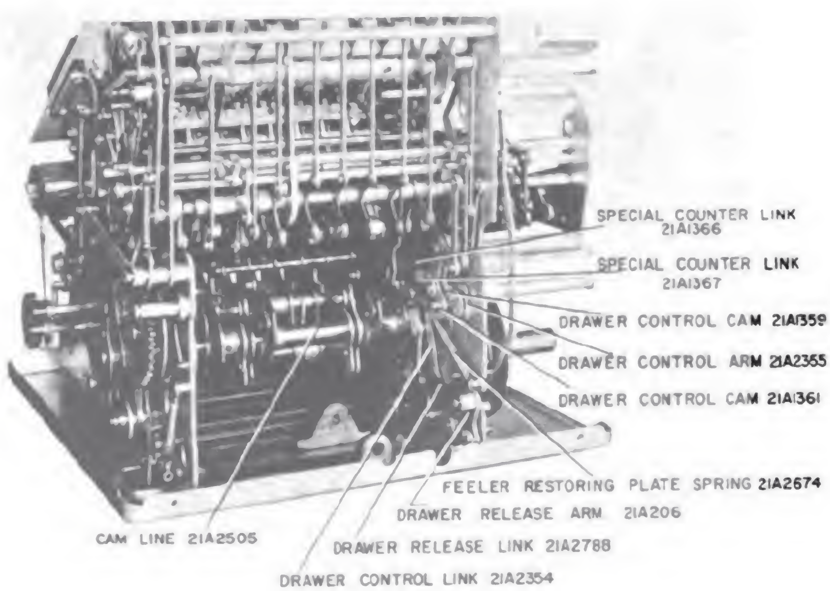

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Figure 15-7.—Nomenclature of a Class 21 National cash register—Continued.

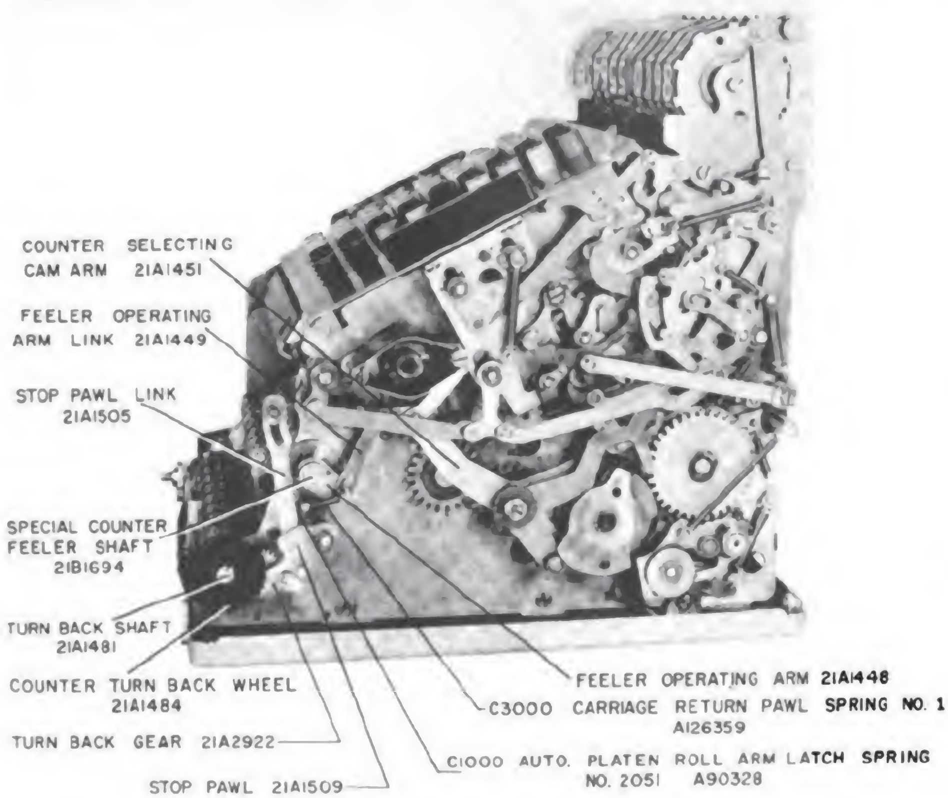

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Figure 15-8.—Nomenclature of a Class 21 National cash register—Continued.

then transferred to a storage total when the item counter is cleared. The storage counter and the item counter have a capacity of $9,999.99. each.

MECHANISMS AND PARTS

By necessity, the mechanisms in a cash register are complex. They are precision-made to function smoothly and accurately, and individually or collectively, in accordance with specific needs. Study the illustrations of mechanisms carefully as you follow the discussion of their operation.

Printer Selecting Plates

The feeding and printing of the receipt (slip of paper with printed record of sale) on the Class 21 National cash register is controlled by four selecting plates located back of the receipt supply roller hub. See figure 15-13. Plate 21A2487 is positioned by the link arm line in row 2 on the keyboard, and plate 21A2171 is positioned by the control lock slide (fig. 15-14). Torsion springs between printer selecting plates 21A2164 and 21A2160 hold them against studs in plates 21A2487 and 21A2171. The positions of the last two plates determine the positions of plates 21A2164 and 21A2160.

Turn now to figure 15-15 and study the printer selecting plates in their operating positions. The lower sections of these plates have high, intermediate, and low spots which control the feeding and printing of the receipt. The high spots result in NO feeding and NO printing; the intermediate spots give the amount of printing ONLY and SHORT feeding; and the low spots give the AMOUNT and DATE printing and LONG feeding.

The upper sections of the selecting plates have high and low spots which control the feeding and printing of the detail strip (paper which remains in the machine for auditing purposes). The high spots give NO feeding and NO printing, and the low spots cause the detail strip to feed and receive print.

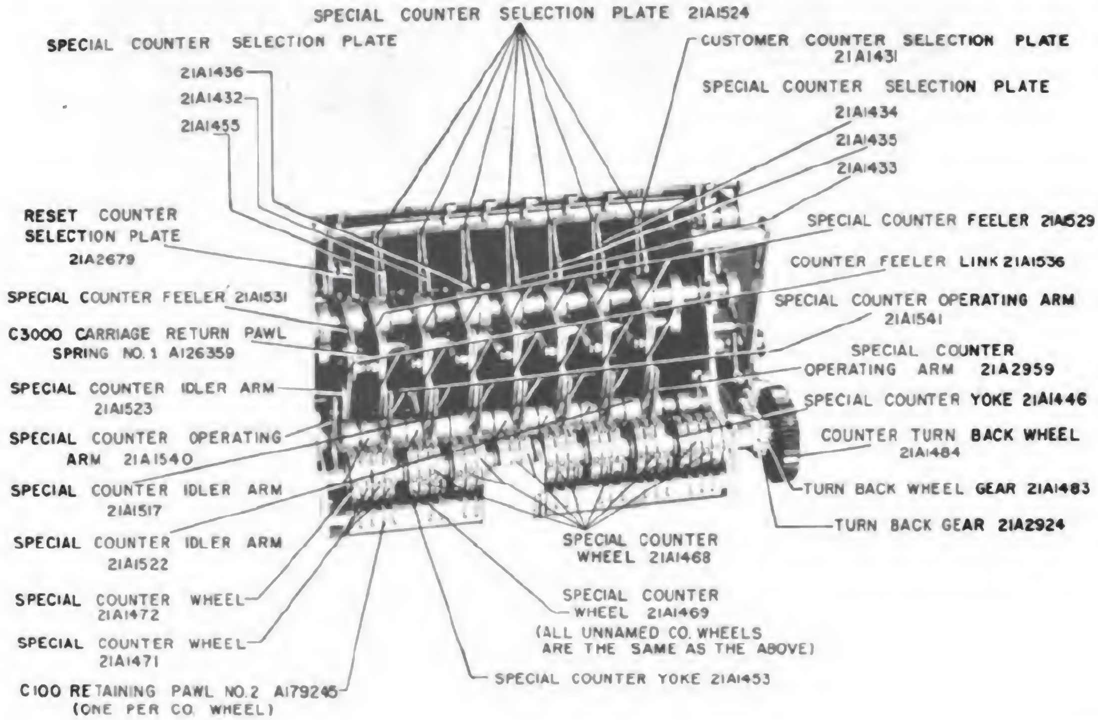

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Figure 15-9. —Nomenclature of a Class 21 National cash register—Continued.

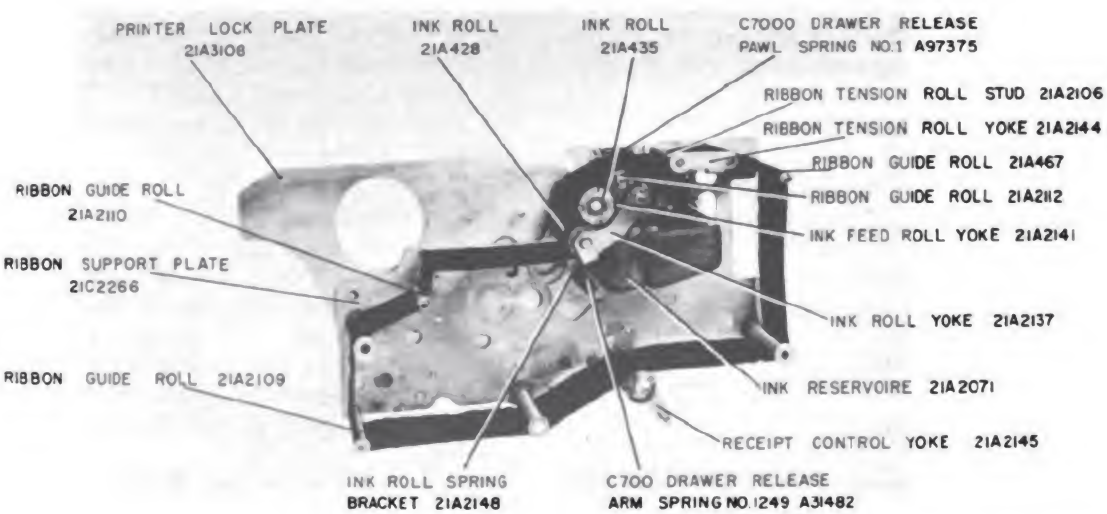

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Figure 15-10. —Nomenclature of a Class 21 National cash register—Continued.

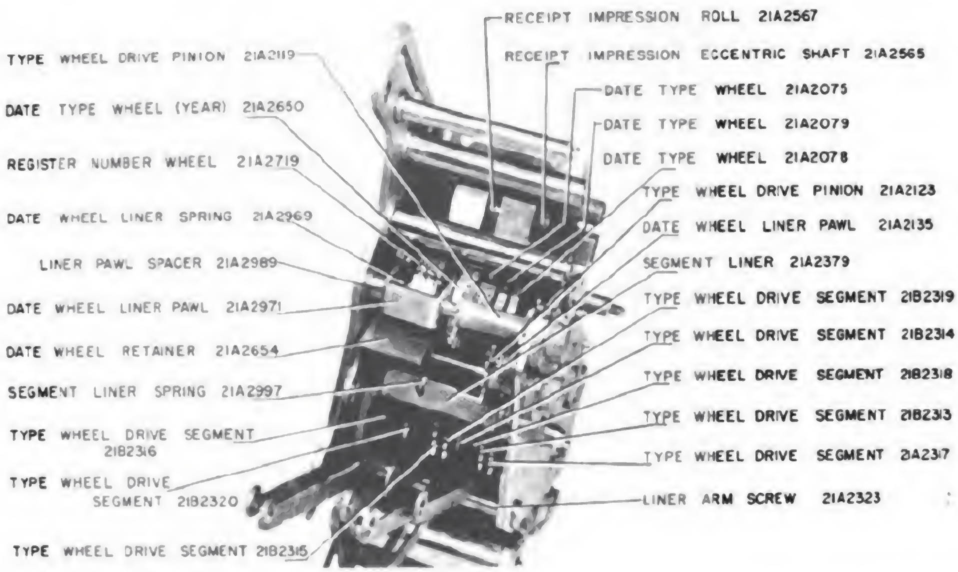

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Figure 15-11.—Nomenclature of a Class 21 National cash register—Continued.

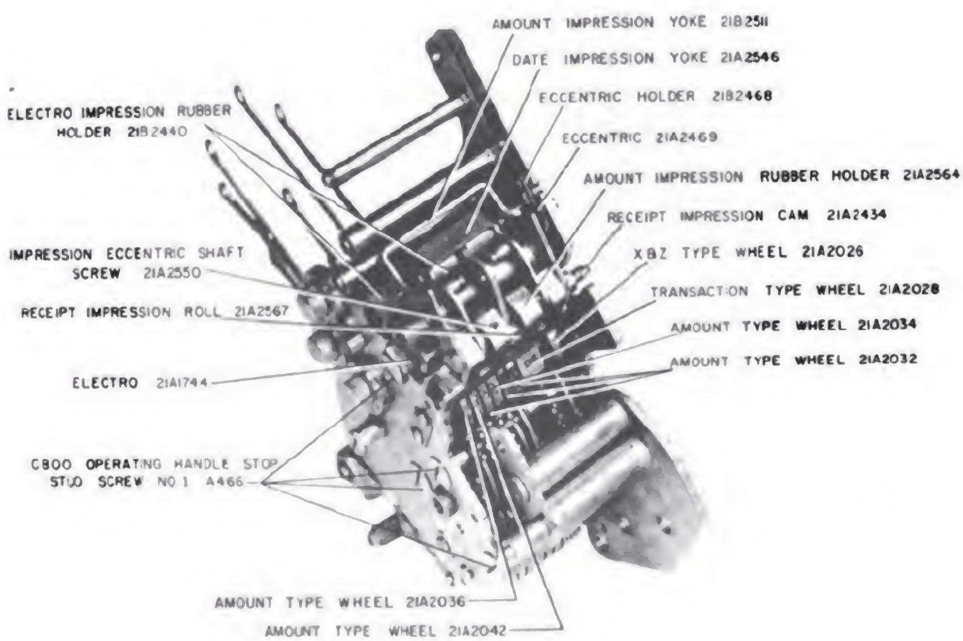

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Figure 15-12.—Nomenclature of a Class 21 National cash register—Continued.

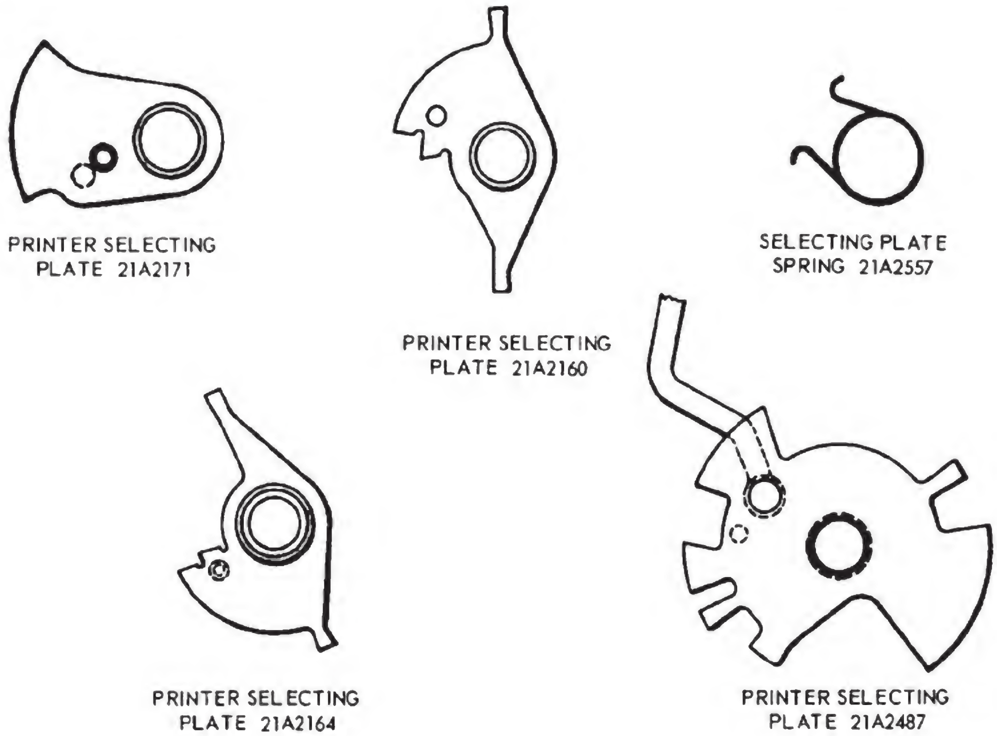

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Figure 15-13.—Printer selecting plates.

On and off Receipt Control Yoke

If the control lock slide (fig. 15-14) is in any position except RESET, a high spot on selecting plate 21A2171 gets in the path of the receipt control yoke. Illustration 15-14 shows the control lock slide in the REGISTERING position.

When the receipt control yoke is in the OFF position, the lower portion of the receipt ON-and-OFF arm is over the receipt impression feeler (illustrated). This portion of the receipt ON-and-OFF arm corresponds to a high spot on the printer selecting plates and disables the feeding and printing of the receipt.

When the receipt control yoke is moved from one position to the other, the stud in the lower end of the receipt ON-and-OFF arm forces the front end of the receipt ON-and-OFF control arm down and oscillates the second control arm from the top to the front of the machine to build up tension in the control spring. The upper end of the control arm has a TURNED-OVER part which enters a low spot in selecting plate 21A-2171. After the stud in the lower end of the receipt ON-and-OFF arm passes over the receipt ON-and-OFF control arm, the control arm spring (illustrated) pulls the control arm from the top to the back of the machine and the upper end of the control arm moves out of the LOT spot in the selecting plate.

Feeler Restoring Plate

The feeler restoring plate (fig. 15-16) is located back of the printer selecting plates, next to the left side frame. When the handle is turned 1/2 turn (180°) from its normal rest position (HOME), the restoring plate is held with the top up and to the FRONT of the machine by three rollers on the inside printer operating cam. In this position, the restoring plate holds both impression feelers clear of the selecting plates while they are being positioned.

At the completion of a 1/2 turn of the handle (crank), the rollers on the printer operating cam move away from the feeler restoring plate and the feeler restoring plate spring pulls the restoring plate to the BACK of the machine, thereby allowing the feelers to move in and FEEL for HIGH or LOW spots on the selecting plates.

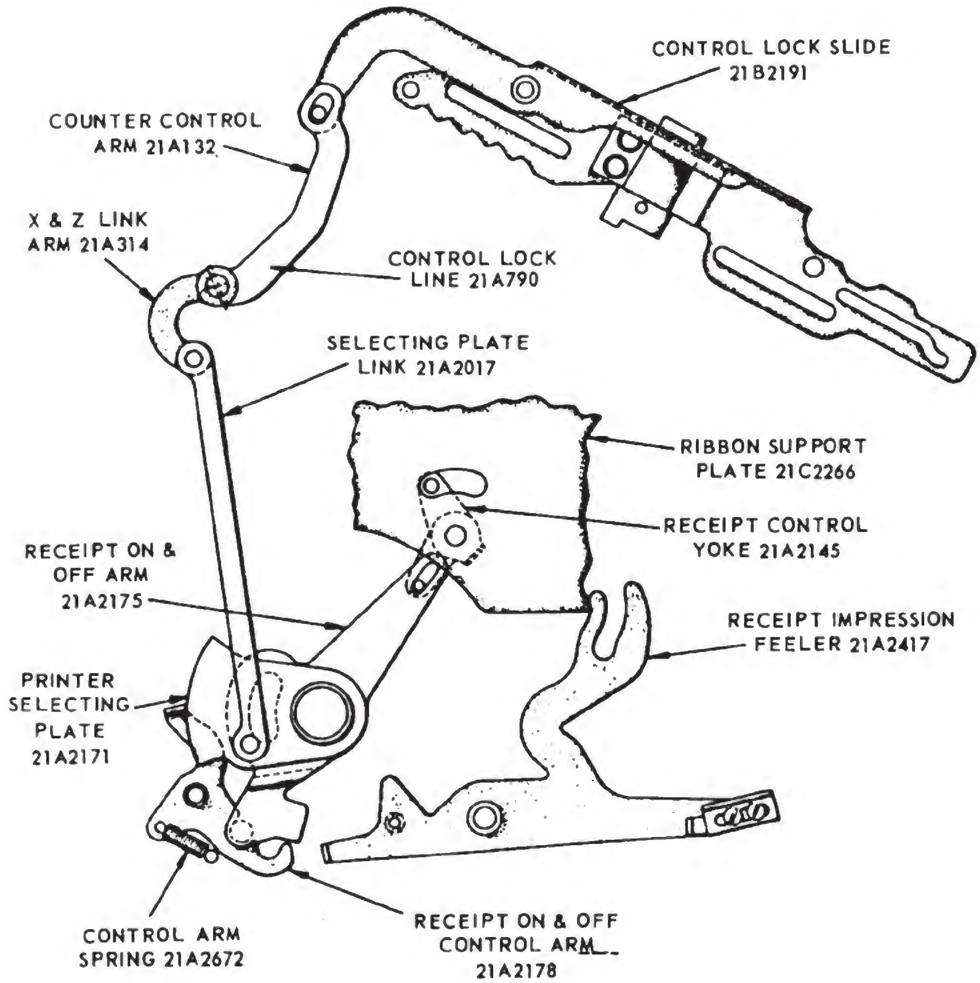

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Figure 15-14. —ON-and-OFF receipt control yoke.

Receipt Impression Pitman

The upper end of the receipt impression pitman (fig. 15-16) swings on a stud in the receipt impression cam, and it has a spring which pulls its lower end toward the front of the machine. A stud in the front end of the impression arm (fig. 15-17) works in an opening in the lower end of the pitman. As illustrated in figure 15-16, the opening in the pitman has a NEUTRAL portion and two WORKING portions (single and multiple). In the rest (HOME) position, the stud in the impression arm is in the center of the neutral portion.

The upper extension of the receipt impression feeler (fig. 15-16) fits over a stud in the pitman; and if a high spot on one of the printer selecting plates is positioned over the feeler during the operation, the neutral portion of the pitman remains over the stud in the impression arm.

When in the HOME position, the impression arm (fig. 15-17) is on the intermediate part of the printer operating cam (fig. 15-6, & 21A2495 figs. 15-17 & 15-18). The first movement of the arm is from TOP to BACK when the handle is turned 3/4 the distance around. Upon completion of a FULL turn of the handle, the arm returns to the intermediate part of the cam. At the completion of one and 3/8 turns of the handle, the arm oscillates TOP to FRONT; and with the stud in the impression arm in the neutral portion of the opening in the pitman, the pitman does NOT move and NO printing occurs on the receipt.

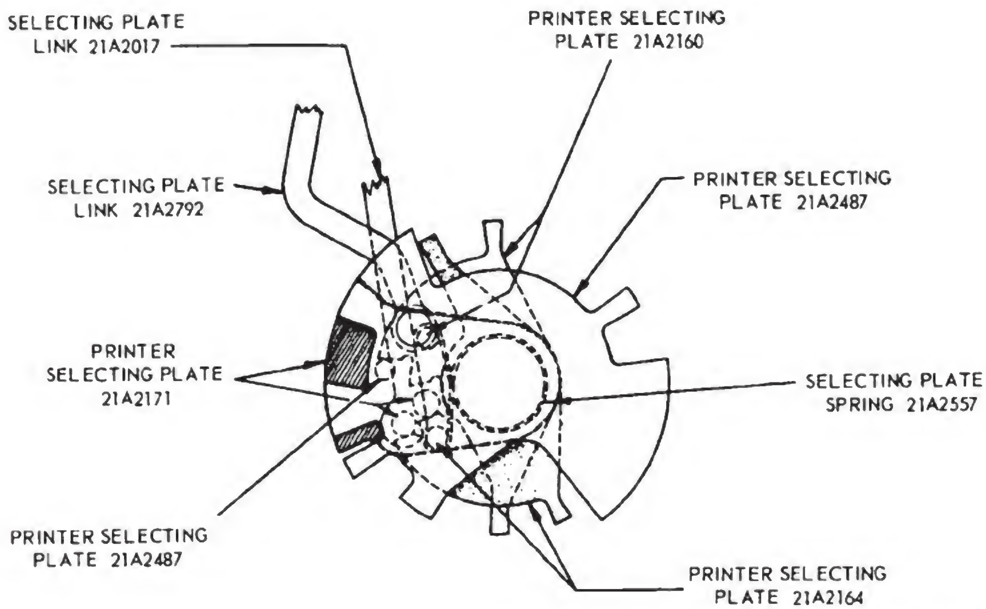

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Figure 15-15.—Printer selecting plates in their operating positions.

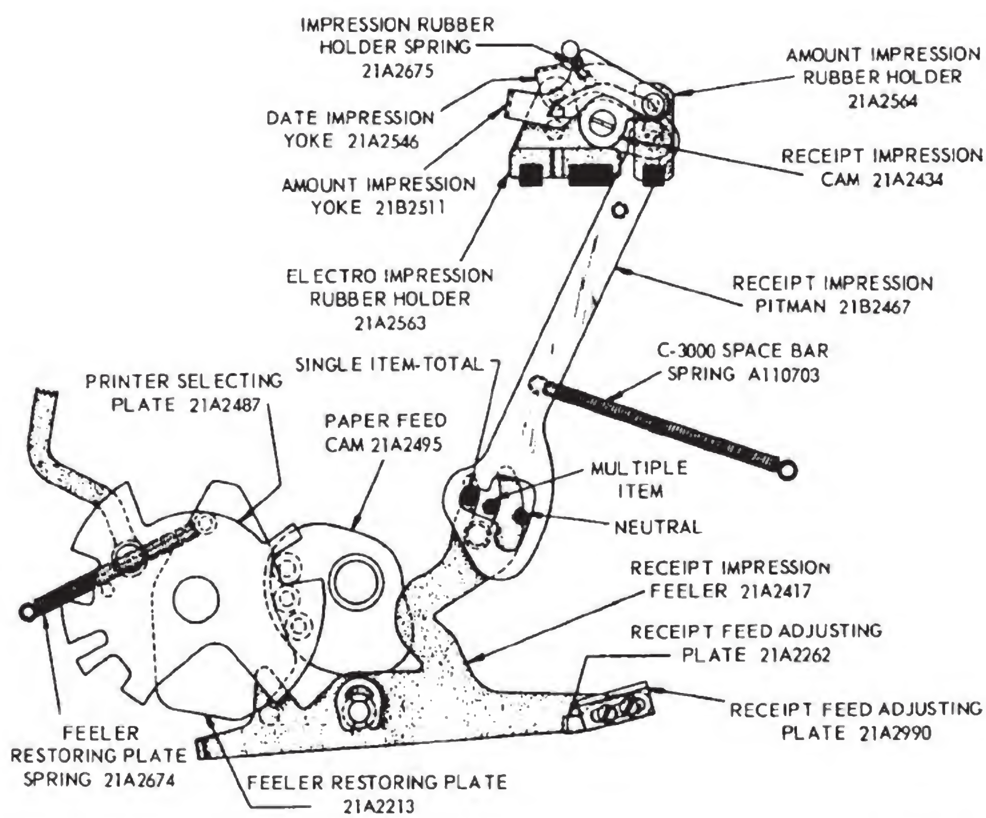

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Figure 15-16.—Feeler restoring plate and attached parts and mechanisms.

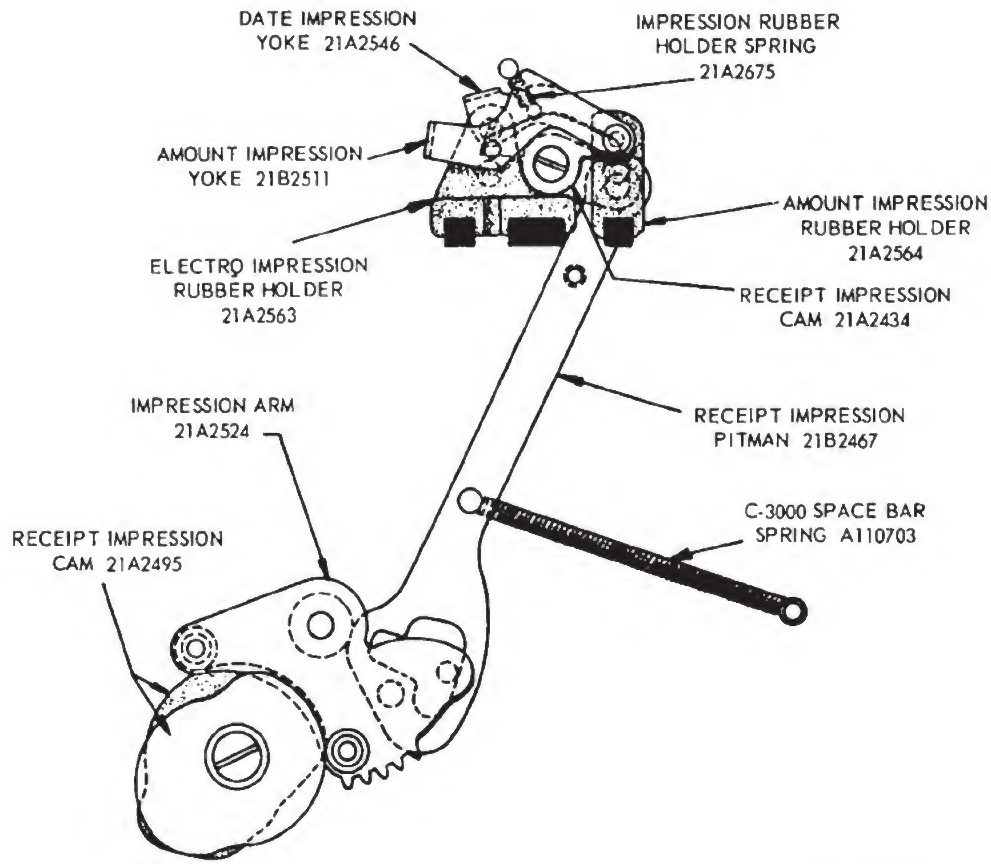

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Figure 15-17.—Receipt impression pitman and connected parts and mechanisms.

If the intermediate spots on the selecting plates are positioned over the receipt impression feeler (fig. 15-16), the receipt impression pitman moves to the FRONT and places the first WORKING portion of the opening under the stud in the impression arm. This portion of the opening is so cut that when the impression arm oscillates TOP to BACK as the handle is turned 3/4 the distance around, the stud does NOT contact the pitman; but when the arm oscillates TOP to FRONT after the handle is turned one and 3/8 turns, the stud DOES contact the pitman and carry it DOWN to print amounts on the receipt.

When LOW spots on the selecting plates are positioned over the receipt impression feeler, the receipt impression pitman moves to the FRONT and places the SECOND working portion of the opening in the pitman over the stud in the impression arm. This position of the opening is so cut that the stud in the impression arm contacts the pitman when the handle is turned 3/4 the distance around and forces it UP to print the date and electro (name plate of firm, etc.) on the receipt. If the handle is turned one and 3/8 turns, the stud carries the pitman down to print the amounts on the receipt.

Studs in the FRONT and BACK printer support plates (fig. 15-5) hold the amount impression yoke (fig. 15-17) on studs. The amount impression rubber holder is assembled to the FRONT of this yoke. The date impression yoke is attached to both the amount and the electro impression rubber holders and the impression rubber holder springs. An upward pull on the date impression yoke holds both impression rubber holders UP off the type in the HOME position.

The receipt impression cam swings on a stud in the back printer support plate, and it has extensions to the FRONT and to the BACK over the amount and the electro impression rubber holders.

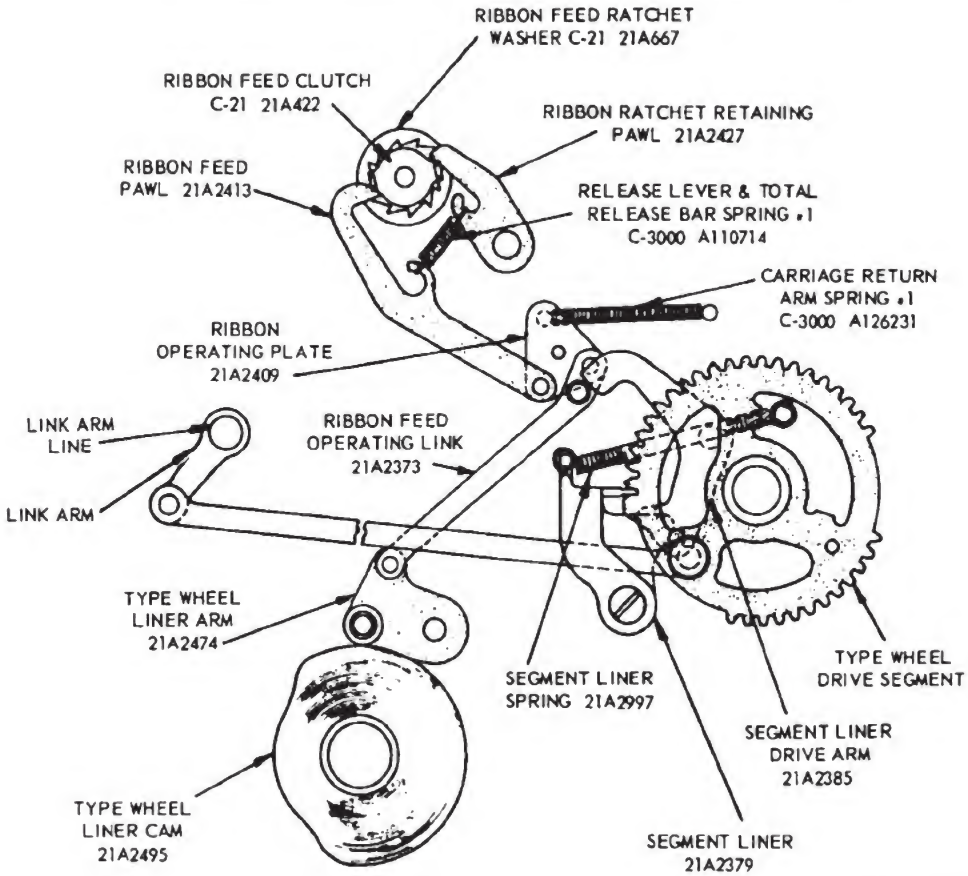

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Figure 15-18.—Type wheel aligning and ribbon feeding mechanism.

When the receipt impression pitman (fig. 15-17) moves UP, it oscillates the impression cam from the top to the back of the machine, and the back extension of the cam then forces the electro impression rubber holder DOWN against the type to print.

When the receipt impression pitman is moved DOWN below the HOME position, the receipt impression cam oscillates TOP to FRONT and carries the amount impression rubber holder DOWN to print the amounts on the receipt.

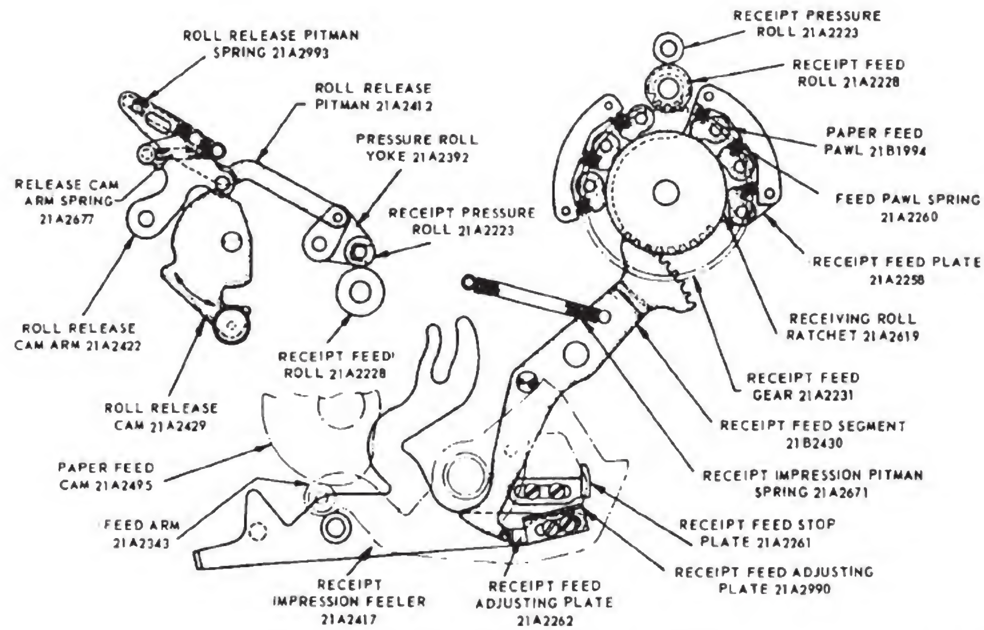
Printer Operating Cam

The printer operating cam (figs. 15-6 & 15-17) is a cluster of four cams on the left end of the printer cam line (fig. 15-7). The two OUTSIDE cams operate the detail and receipt impression mechanism (receipt impression cam), illustrated in figure 15-17. The third cam from the outside operates the type wheel liner arm (fig. 15-18). The type wheel liner arm operates both the liner and the ribbon feed mechanism (type wheel liner cam).

Three rollers on the side of the inside cam of the cluster operate the feeler restoring plate (fig. 15-16). The surface of the cam operates the paper feeding mechanism (fig. 15-19) for BOTH the detail and the receipt paper (paper feeding cam).

Paper Feeding Mechanism

The receipt impression feeler (fig. 15-16) also controls the feeding of the receipt paper. The receipt feed adjusting plate (21A2262, fig. 15-19) is located slightly LOWER on the feeler than feed adjusting plate 21A2990. When a high spot on one of the selecting plates is positioned over the receipt impression feeler, adjusting plate 21A2262 is in the PATH of receipt feeding segment 21B2430 (fig. 15-19) and does NOT let



91.415X

Figure 15-19.—Paper feeding mechanism.

the segment COCK the receipt feeding mechanism; so the receipt paper does NOT feed.

When INTERMEDIATE spots on the printer selecting plates are positioned over the receipt impression feeler (fig. 15-16), the front extension of the feeler moves DOWN slightly and the receipt feeding adjusting plate (fig. 15-19) is moved DOWN and OUT of the path of the receipt feeding segment. Receipt feeding adjusting plate 21A2990 is secured slightly HIGHER and a little to the FRONT of adjusting plate 21A2262; and when the receipt impression feeler is on an intermediate spot on the selecting plates, adjusting plate 21A2990 is IN THE PATH of the receipt feeding segment. When in this position, plate 21A2990 allows the receipt feeding segment to move TOP to BACK far enough to cock the receipt feeding mechanism sufficiently to feed the paper 1/4 inch.

When LOW spots on the selecting plates are positioned OVER the impression feeler, the front extension of the feeler moves DOWN and carries BOTH adjusting plates OUT of the path of the receipt feeding segment. The segment then moves BOTTOM to FRONT until it is stopped by the receipt feeding stop plate (21A-2261) screwed to the left side frame. This movement COCKS the receipt feeding mechanism for LONG feeding.

Type Wheel and Ribbon Feeding Mechanism

Movement to position the type wheels (fig. 15-11) is provided by the link arm lines (fig. 15-18). Differential links swing on studs in the link arms pinned to the link arm lines outside the left side frame. The front end of the differential links swings on studs in the type wheel drive segment (fig. 15-18). This mechanism positions the drive segments, which (in mesh with the type wheels) then position the type wheels.

One complete turn of the handle fully positions the type wheels. Just after the completion of one turn of the handle, the LOW part of the printer operating cam (fig. 15-17) comes UNDER the roller and stud on the type wheel liner arm (21A2474, fig. 15-18) and the segment liner spring pulls the segment liner (fig. 15-18) from the top to the front of the machine and into the teeth of the type wheel drive segments, thereby aligning the segments and type wheels.

As the segment liner moves into the teeth of the segments, it contacts the segment liner drive arm and moves it TOP to BACK. The segment liner drive arm (fig. 15-18) swings on a stud in the back printer support plate, and the top of the arm moves to the back and contacts a stud in the ribbon feeding operating link which

extends through an opening in the back printer support plate. The link is then forced to the BACK of the machine to cause the roller and stud on the type wheel liner arm to follow the surface of the printer operating cam.

The upper end of the ribbon feeding operating link (fig. 15-18) is attached to the ribbon operating plate; and as the link moves to the back, the plate is turned TOP to FRONT. The lower end of the ribbon feeding pawl (fig. 15-18) is attached to the ribbon operating plate, and the upper end of the pawl is held against the ratchet of the ribbon feeding clutch by spring tension. As the operating plate turns TOP to FRONT, it carries the feeding pawl up and cocks the ribbon feeding mechanism. The ribbon ratchet retaining pawl (fig. 15-18) keeps the ribbon feeding clutch from turning when the pawl moves over the ratchet.

Just before the handle completes one and 3/4 turns, the HIGH part of the printer operating cam (21A2405, fig. 15-17) comes UNDER the roller and stud in the type wheel liner arm and forces the arm UP. The ribbon feeding operating link then moves UP and to the FRONT of the machine. The stud in the upper part of the link contacts the segment liner drive arm and moves it TOP to FRONT. The lower part of the segment liner drive arm then contacts the segment liner and carries it out of the teeth of the segments.

The ribbon feeding operating link also turns the ribbon operating plate TOP to BACK. The ribbon feeding pawl is then moved DOWN to turn the ribbon feeding clutch TOP to BACK. The ribbon feeding clutch continues the action by turning the ink roller (fig. 15-10) TOP to BACK to feed the ribbon ONE position.

Multiple-item Operations

From the HOME position to a 1/2 turn of the handle, the rollers on the printer operating cam hold the feeler restoring plate (fig. 15-16) TOP to FRONT. In this position, the restoring plate holds the impression feelers clear of the HIGH spots on the selecting plates while they are being positioned.

A 3/8 turn of the handle fully positions the selecting plates; at the completion of 1/2 turn of the handle, the rollers on the printer operating cam move AWAY from the feeler restoring plate and this plate's spring then pulls the plate TOP to BACK.

The upper extension of the receipt impression feeler (fig. 15-19) yokes over a stud in the receipt impression pitman, and a spring pulls this pitman to the front of the machine to cause the feeler to move UP in the BACK until it contacts an intermediate spot on the printer selecting plates.

The receipt impression pitman then moves to the FRONT and places the first working portion of the opening in it over the stud in the impression arm (fig. 15-17) to set up a condition for the amounts ONLY to be printed on the receipt paper.

The front of the receipt impression feeler (fig. 15-19) moves DOWN and positions adjusting plate 21A2990 in the path of the receipt feeding segment, thereby setting up a condition for SHORT feeding of the receipt paper.

In the HOME position, the high part of the printer operating cam is over the roller and stud in the back part of the feed arm (fig. 15-20) and thus holds it down. The front of the feed arm is against a stud in the receipt feeding segment (fig. 15-19) and thus holds the segment TOP to FRONT.

Just after a 1/2 turn of the handle, the LOW part of the cam moves over the roller and stud in the feed arm, and the receipt feeding segment spring pulls the receipt feeding segment TOP to BACK until it is stopped by the receipt feeding adjusting plate. The receipt feeding segment is in mesh with the teeth on the receipt feeding plate (fig. 15-19) and turns the plate TOP to FRONT. Three paper feeding pawls (fig. 15-19) assembled on the receipt feeding plate are held against the teeth of the receiving roller ratchet by the feed pawl spring. As the receipt feeding plate turns TOP to FRONT, the pawls move over the teeth of the receiving roller ratchet and COCK the feed mechanism for SHORT feeding.

If the handle is turned 3/4 the distance around, the high part of the printer operating cam forces the front roller on the impression arm (fig. 15-17) to the front of the machine. The stud in the impression arm moves up but does NOT give any movement to the impression pitman, because the receipt impression feeler is on the INTERMEDIATE spots on the selecting plates.

One complete turn of the handle fully positions the type wheels; one and 1/4 turns of the handle position the HIGH part of the printer operating cam (fig. 15-18) under the back roller and stud on the impression arm and move it

UP in the back. The stud in the front of the arm moves DOWN and carries the receipt impression pitman along. The upper end of the pitman is connected to the receipt impression cam and oscillates it TOP to FRONT, and carries the amount impression rubber holder (fig. 15-17) DOWN against the type to print the amounts on the receipt paper.

Upon the completion of one and 3/4 turns of the handle, the rollers on the inside printer operating cam contact the feeler restoring plate (fig. 15-16) and move it TOP to FRONT to restore the impression feelers to their rest positions.

When the handle is turned one and 1/2 times, the high part of the printer operating cam moves the feed arm DOWN in the back. On an item operation, however, the front of the feed arm does NOT contact the stud in the receipt feeding segment until the handle has been turned one and 7/8 turns, because the segment is stopped by the receipt feeding adjusting plate.

Upon the completion of one and 7/8 turns of the handle, the feed arm moves the receipt feeding segment TOP to FRONT. The segment then turns the receipt feeding plate TOP to BACK and the feed pawls turn the receiving roller ratchet and the receipt feeding gear TOP to BACK. The receipt feed gear, in mesh with the pinion on the receipt feeding roller (fig. 15-19), turns the roller TOP to FRONT. Gripped between the receipt feeding roller and the receipt pressure roller, the paper then feeds 1/4 inch.

The following discussion is for feeding and printing of the receipt paper on TOTAL and CASH 1 operations, with the ON-and-OFF lever in the ON position.

Operation of the receipt mechanism on all TOTAL and CASH 1 operations is similar to the operation for multiple-items. The only difference is that LOW spots in the selecting plates are placed over the receipt impression feeler (fig. 15-19) to allow the feeler to move TOP to FRONT far enough to place the SECOND working portion of the opening in the receipt impression pitman over the stud in the impression arm. This action sets up a condition for printing the date and the amounts on the receipt paper.

Low spots in the selecting plates also allow the receipt impression feeler to move DOWN far enough in the FRONT for both receipt feeding adjusting plates (fig. 15-19) to clear the tail of the receipt feeding segment. Downward movement of the receipt impression feeler permits the receipt feeding segment to move TOP to BACK until it is stopped by the receipt feeding stop plate (fig. 15-19), screwed to the left side frame, to cock the receipt feeding mechanism for LONG feeding.

During subtotal operations, a HIGH spot is over the receipt impression feeler and the receipt mechanism is disabled.

Detail Mechanism

The detail mechanism (figs. 15-20 and 15-21) on the Class 21 National cash register is constructed so that all items and their total, or just the total of the items, print on the detail strip (audit slip). For item printing on the detail strip, a LOW spot should be on the printer selecting plates under the detail impression feeler (fig. 15-20). If the total ONLY of the items is desired on the detail strip, a high spot should be under the detail impression feeler on item operations.

From HOME to 1/2 turn of the handle, the detail impression feeler is held away from the selecting plates in the same manner as the receipt impression feeler, so that the selecting plates can be positioned. Upon completion of a 1/2 turn of the handle, the rollers on the printer operating cam (fig. 15-20) move away from the feeler restoring plate (fig. 15-16) and spring tension pulls the plate from the top to the back of the machine. Another spring which pulls up on the front of the feeler carries it DOWN in the back to FEEL for high and low spots on the selecting plates.

If there are low spots under the receipt impression feeler, it moves down in the back and the front end raises the back extension of the detail control arm (fig. 15-20). The lower, front extension of the control arm is then moved far enough to the back to clear the hook on the detail feed stop pawl (fig. 15-20). The control arm also has an extension which yokes a stud in the detail impression cam link; and the arm moves the link to the back of the machine to place the stud in the link in the path of the step on the detail impression plate (fig. 15-21).

As the handle completes one and 1/4 turns, the impression arm in the back rises to turn the detail impression plate TOP to BACK. The step on the impression plate contacts the stud in the detail impression cam link and forces it up. The link is attached to the detail cam arm

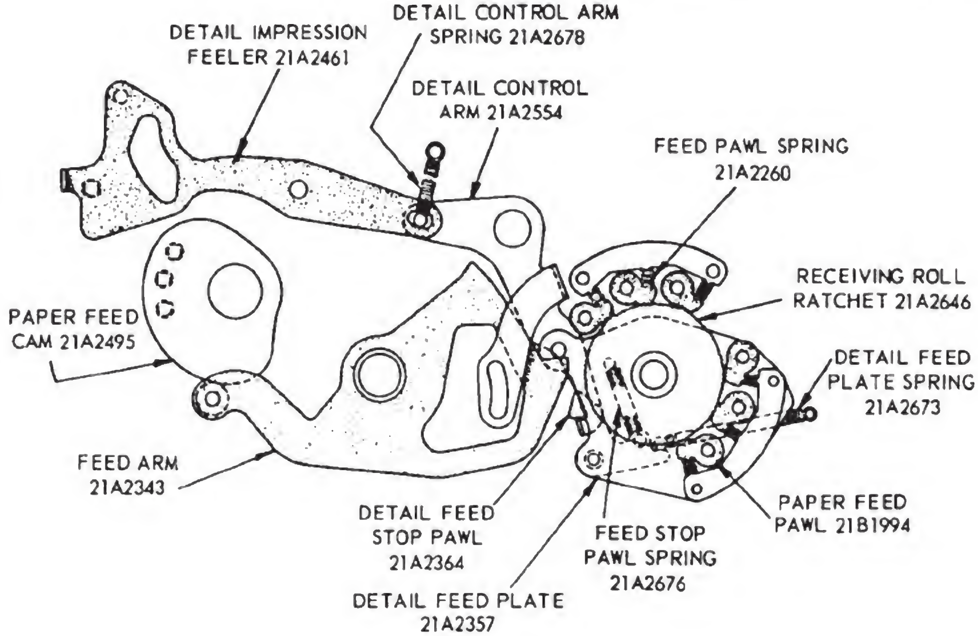


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Figure 15-20. —Detail strip printing and feeding mechanism.

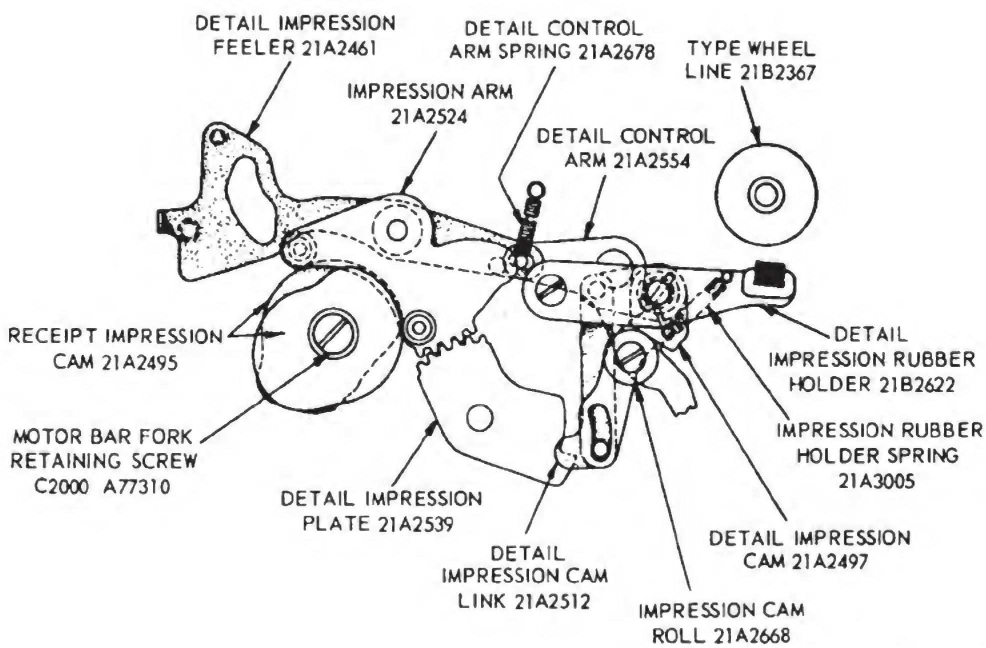

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Figure 15-21. —Detail strip printing and feeding mechanism (cont.).

and the arm is turned TOP to FRONT. The detail cam arm is pinned to the right end of the detail cam shaft, and the shaft extends to the left through the two extensions of the detail impression rubber holder. The detail impression cam is pinned to the cam shaft between the extension of the impression rubber holder.

As the detail cam shaft turns TOP to FRONT, the high part of the detail impression cam (fig. 15-21) moves over the impression cam roller, which fits over a stationary stud in the back printer support plate. Movement of the high part of the cam over this roller causes the detail cam shaft to rise and the cam shaft to carry the detail impression rubber holder up to print on the detail strip.

As soon as the handle is turned one FULL turn, the low part of the printer operating cam moves over the roller on the feed arm and allows it to move down in front. Spring tension then turns the detail feed plate from TOP to BACK to cock the detail feeding mechanism.

At approximately one and 1/2 turns of the handle, the high part of the printer operating cam moves over the roller on the feed arm (fig. 15-20) and forces it down in the back. The front end of the feed arm then contacts the stud in the detail feed plate and turns it TOP to FRONT to space the detail.

Special Counters

There is a special, a customer, and a reset counter in the Class 21 receipt printer for each key in ROW 2 (except subtotal key). Study figures 15-9 and 15-22. Each time the CASH 1 or the CASH TOTAL key is used the special counter marked CASH adds 1. All other keys in ROW 2 add on their own counters each time they are used when the control lock slide (fig. 15-14) is in the registering position.

The customer counter adds 1 each time a key in ROW 2 is used (subtotal, tax, and no-sale keys excluded). Special counters do NOT add during multiple-item operations.

With the exception of the reset counter, each special counter has a selecting plate (fig. 15-9) positioned by the transaction row which controls the selection of the counters when the control lock slide is in the registering position. A low spot in a selecting plate over one of the special counter feelers selects that counter to add; a high spot disables it.

The CASH, CUSTOMER, and CHARGE counters also have selecting plates positioned by the control lock slide. When the control lock slide is moved out of the registering position, these selecting plates place high spots over the special counter feelers to disable addition on the counters.

The reset counter is controlled by the control lock slide, and it adds one each time the register is operated with the control lock slide in the reset position.

The discussion which follows is for the selection of special counters from the TRANSACTION ROWS when the control lock slide is in the registering position.

Special counter link 21A1366 (fig. 15-22) is connected to drawer control cam 21A1359, which is positioned by the transaction row link arm line. The front end of the link is connected to the selection plate shaft (fig. 15-22). The special counter selection plates which control addition on the special counters when the control lock slide is in the registering position are pinned to the selection plate shaft, and they are positioned by the mechanism just described in such manner that a low spot is over the feeler of the special counter which corresponds to the key in use in row two.

A low spot in the selecting plate over the special counter feeler allows the feeler to move TOP to FRONT when the feeler stop shaft moves to the back as the handle is turned 1/2 turn.

The upper end of the counter feeler link (fig. 15-22) is attached to the front end of the special counter feeler, and the lower end of the link has a stud which extends to the right through an elongated hole in the special counter idler arm, and then over a DWELL in the special counter operating arm. As the special counter moves TOP to FRONT, the counter feeler link moves DOWN and the stud in the link enters the dwell in the special counter operating arm to set up a condition for that counter to add.

When a high spot on the selecting plate is positioned over the special counter feeler (fig. 15-22), the feeler cannot move TOP to FRONT far enough for the stud in the counter feeler link to enter the dwell in the special counter operating arm and the counter therefore does not add.

DISASSEMBLY

Disassembly of a Class 21 cash register is explained in the following paragraphs. Refer to

applicable illustrations in this chapter as you study the procedure, step by step.

1. Remove the ribbon assembly and the lower printer support plate (fig. 15-10). NOTE: When you do this work in an instrument shop, refer to the manufacturer's technical manual for the machine.

2. Remove the feed roller support plate and the receipt feed roller.

3. Take off the receipt and detail supply roller hubs and the detail receiving roller.

4. Remove the printer unit by: (a) unhooking the back end of the type wheel drive segment links and pushing the links to the front, and (b) by removing the four screws which hold the unit to the left side frame.

5. Unhook the upper end of the link connected to printer selecting plate 21A2487. Remove the clip which holds the selecting plate on the stud and turn the selecting plate TOP to BACK until it clears the printer operating cam and then remove it.

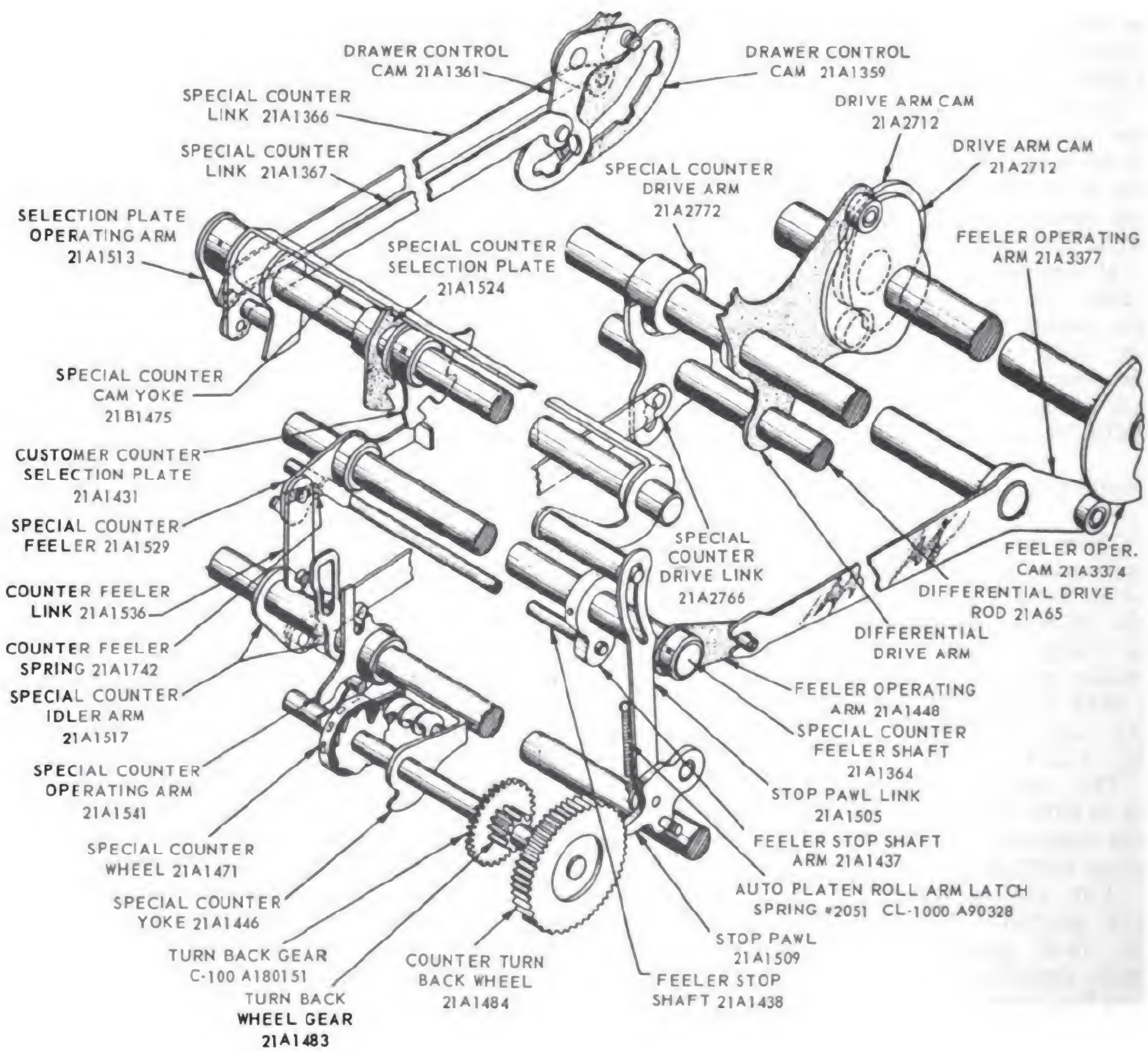

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Figure 15-22. —Special counter selection mechanism.

6. Remove printer selecting plates 21A2164 and 21A2160 and the ON-and-OFF arm.

7. Remove the detail impression plate.

8. Remove the receipt feed gear, the receipt receiving roller ratchet, and the receipt feed plate. CAUTION: Protect the feed pawl springs.

9. Turn the handle of the register one and 1/2 turns and then remove the screw in the left end of the cam line. Hold the feed arm and the receipt impression feeler down in the back and remove the impression arm and the printer operating cam at the same time.

10. Remove the type wheel liner arm and the ribbon operating plate; then remove the detail impression feeler.

11. Slide the feed arm out slightly and remove the receipt feed segment and the detail control arm.

12. Remove the feed arm and the receipt impression pitman.

13. Take off the printer selecting plate (21A2171) and the feeler restoring plate.

14. Unhook the spring on the detail paper feeler and turn the detail feed plate TOP to FRONT and remove the feeler.

15. Remove the detail receiving roller ratchet and the detail feeding plate.

The disassembly procedure for the printer unit is as follows:

1. Remove the detail impression rubber holder, the segment liner, and the roller release cam, in the order listed.

2. Unhook the springs and remove the spring shaft.

3. Remove screws from the printer support plate and the clip from the stud in the plate which holds the AMOUNT impression yoke. Then remove the printer support plate.

4. Remove the amount and date impression rubber holder and the date setting knobs.

5. Remove the electro and printer support plate (21A2129).

6. Take out the type wheels and the type wheel shafts (receipt and detail). NOTE: Keep type wheels on the shafts.

7. Remove the date wheels and their drive pinions, and then the type wheel drive segments.

To remove the special counters, do the following:

1. Remove the screws from the sides of the counter turn back shaft brackets. Then take out the trunnion from the left end of the counter turn back shaft, and remove the turn back wheel and gears. NOTE: Do NOT remove the pin from gear 21A180151. Slide the turn back shaft to the right, and also the trunnion on the right end of the shaft. Then operate the register until the special counter idler arms move to the back and remove the turn back shaft assembly.

2. Unhook and remove the reset counter feeler link.

3. Unhook the front end of the special counter drive link and slide the trunnion on the right end of the counter operating shaft to the left. Then slide the entire shaft to the right and remove it.

4. Remove the trunnion on the right end of the special counter feeler shaft and take out the shaft.

5. Remove the trunnion on the right end of the selecting plate shaft and then remove the shaft.

NOTE: Reverse the disassembly procedure just described for rebuilding a special counter assembly.

REASSEMBLY

To reassemble a Class 21 cash register, proceed as follows:

1. Replace the detail feeding plate and the detail receiving roller ratchet.

2. Insert the detail paper feeler and hook the spring.

3. Install the feeler restoring plate and the printer selecting plate.

4. Replace the receipt impression feeler and the feed arm.

5. Insert the detail control arm and the receipt feeding segment.

6. Replace the detail impression feeler, the type wheel liner arm, and the ribbon operating plate, in order.

7. Install the receipt impression pitman.

8. Turn the handle one and 1/2 turns and replace the printer operating cam and the impression arm (at the same time).

9. Replace the detail impression plate, the ON-and-OFF arm, and the printer selecting plates.

10. Replace the printer unit. CAUTION: Be sure the stud in the ribbon feed operating link is back of the segment liner drive arm.

11. Replace all remaining parts of the machine. NOTE: When you replace the ribbon assembly, make certain that the stud on the ON-and-OFF yoke is in the elongated hole in the ON-and-OFF arm.

The procedure for rebuilding the printer unit follows:

1. Replace the type wheel drive segments.
2. Insert the date wheels and their drive pistons.
3. Install the printer support plate and put the timing rod through the type wheel drive segments.
4. Remove the detail type wheels from the type wheel shaft. Then start the type wheel shaft and the type wheel timing rod through the support plate and replace the type wheels one by one.
5. Replace the receipt type wheels in the same manner as you replaced the detail type wheels. NOTE: If you can insert a timing rod in all three receipt and detail type wheels and the type wheel drive segments as you reassemble them, they are in TIME.
6. Replace the detail impression rubber holder and the AMOUNT and DATE impression rubber holders.
7. Install printer support plate 21B2530 and the segment liner.
8. Replace the spring shaft and secure the springs.
9. Install the date setting knobs. CAUTION: Be certain the date on the printing line corresponds to the date indicated by the date setting knobs.

ADJUSTMENTS

Some of the adjustments you will be required to make on a Class 21 National cash register are explained in the following pages, as follows:

1. Receipt feeding adjusting plate (21A2262). —Be sure that you have a clearance of 1/32 inch ONLY between the receipt feeding segment and the receipt feeding adjusting plate when it is in the rest position. TOO MUCH clearance allows the segment to cock the receipt feeding mechanism for SHORT feeding, even though a HIGH spot on the selecting plate was positioned over the receipt impression feeler. The small teeth on the receiving roller ratchet and the feeding pawls are responsible for such action.

2. Receipt feeding adjusting plate 21A2990. —Receipt feeding plate 21A2990 is properly adjusted when the receipt paper feeds 1/4 inch during multiple-item operations.

3. Receipt feeding stop plate 21A2261.—The receipt feeding stop plate is secured to the left side frame by screws and it stops the cocking movement of the receipt feeding segment on all LONG feeding operations. It is properly adjusted when the receipt paper feeds one and 7/8 inches on a single-item (CASH 1) operation.

4. Amount and electro impression rubber holders.—The receipt impression cam works on rollers in the amount and electro impression rubber holders. The rollers are assembled on eccentric studs, and you can increase or decrease the impression on the receipt by turning this stud (secured with set screw).

5. Receipt impression pitman.—The HOME position of the receipt impression pitman is determined by two impression pitman locating arms. So adjust the eccentric between the upper extensions of the arms so that the clearance between the edges of the opening in the pitman and the stud in the impression arm is equal above and below the stud when the receipt impression feeler is on a LOW spot in the selecting plates.

If you adjust the pitman in this manner, there is no likelihood that the corners of the opening in the pitman will catch on the stud in the impression arm when the pitman moves to the front of the machine.

6. Special counters.—The special counter drive arm has three adjustment positions, which feature enables you to adjust the amount of carry for the counter wheels. The stud in the special counter drive link is normally in the UPPER position. If more carry is required in the special counter wheels, move the stud to the MIDDLE or LOWER position, as required by the amount of additional carry necessary.

For additional information relative to adjustments of the Class 21 National cash register, or any other information, refer to the manufacturer's technical manual for the machine.

APPENDIX I

GLOSSARY OF TERMS

WATCHES AND CLOCKS

ADJUSTMENT OF BALANCE ASSEMBLY—The manipulation of the balance wheel with its spring and staff to secure the most accurate timekeeping possible. Three adjustments are usually made: for isochronism, temperature, and position. Much of the difference in cost and value of watches depends on this operation.

ADJUSTMENT FOR ISOCHRONISM—Manipulating the balance and balance spring so that the watch does not change its rate when the balance swings through a long arc or a short one.

ADJUSTMENT FOR POSITION—Manipulating the balance and balance spring so that the rate does not change when the watch is in different positions.

ADJUSTMENT FOR TEMPERATURE—Arranging the screws on the compensation balance so that the time of swing will be as nearly as possible the same for a considerable range of temperature. (Seldom necessary today.)

ALLOY—A mixture of two or more metals.

ARBOR—The axle on which a wheel turns.

ARKANSAS OILSTONE—A smooth oilstone (hard or soft) used for sharpening gravers, screw drivers, and tools of all kinds to a final finish.

BACKLASH (WATCH)—A small reverse movement of the wheels at the end of unwinding.

BALANCE ARC—In detached lever escapements, that part of the vibration of the balance in which it is connected with the train.

BALANCE ARM—The flat piece of metal across the center of the balance wheel which supports the balance wheel on the balance staff.

BALANCE ASSEMBLY—The balance wheel and its arbor, complete with hairspring and roller assembly.

BALANCE COCK—The projecting bar which holds one end of the balance arbor.

BALANCE SPRING—(Also called hairspring.) A fine, coiled wire, one end of which is attached to a collet fitted friction-tight on the balance staff and the other end to a stud on some stationary part of the watch, (as on balance cock or watch plate.) This spring governs the time of vibration of the balance.

BALANCE STAFF.—The axis or arbor which carries the balance wheel.

BALANCE TRUING—Bending balance wheel rims back into shape to obtain perfect balance.

BALANCE WHEEL—The oscillating wheel of a watch, which, along with the balance spring, regulates the motion of the train, thus controlling the movement of the hands.

BANKING—the striking of the outside of the lever by the impulse pin due to excessive vibration of the balance.

BANKING PINS—Pins (two in number) which arrest or limit the angular motion of the lever in the lever escapement of a watch.

BANKING TO THE DROP—Positioning the banking pin to a point where the escape wheel teeth will just clear or let off the pallet.

BARREL—The circular metal box which contains the mainspring.

BARREL, GOING—The type of mainspring barrel having teeth cut around the outside; these teeth are in mesh with the center wheel pinion. This driving action furnishes the motive power for the watch.

BARREL HOOK—A bent pin in the barrel to which the mainspring is attached.

BARREL RATCHET—A wheel on the barrel arbor which is prevented by a dog from turning backward while the mainspring is being wound and which becomes the base against whose resistance the train is driven.

BEARING, JEWELED—A metal support inlaid with specially formed small ruby, sapphire, or diamond to minimize the friction of a pivot or pin.

BEAT—One vibration of the balance and balance spring resulting from an impulse received by means of an escapement. (See Inbeat.)

BEZEL—The grooved metal ring which holds in place the crystal or glass of a watch or clock.

BRIDGE—One of the upper plates used for the support of the wheels; the central part is cut away to provide space for one or more pivot bearings.

BURNISHED PIVOT—Highly polished end of a rotating arbor.

BURR—A small piece of metal projecting from a part, such as that left on a new wheel by a gear cutter or caused by wear between gear teeth.

CANNON PINION—The pinion with a long pipe to which the minute hand is fixed.

CAPPED JEWEL—A jewel having a protective endstone.

CENTER STAFF—The arbor attached to the center wheel which carries the minute hand.

CENTER WHEEL—The wheel in ordinary clocks and watches placed in the center of the frame on whose arbor the minute hand is carried. It is intermediate between the barrel and the third wheel.

CHRONOMETER—Any very accurate timekeeper. Usually understood to mean a timekeeper fitted with a spring detent escapement, also with a fusè (stepped barrel) and a cylindrical balance spring.

CHUCK—A device inserted in the headstock of a lathe to hold the part in position for machining or other lathe operation.

CIRCULAR ESCAPEMENT—An escapement so constructed that the central portion of each pallet stone's impulse face stands at an equal distance from the pallet center.

CLEARANCE—The small space or distance between adjacent parts of a machine by which one part clears another. In the watch trade this space is called ENDSHAKE.

CLICK—A pawl or dog which fits into the teeth of the ratchet wheel and prevents it from turning backwards.

CLUTCH—A device in a stem-wind watch to shift the power from the stem to either the winding or the setting gearing.

CLUTCH LEVER—The lever which operates in a recess of the clutch and moves it into setting or winding position.

CLUTCH PINION—The pinion surrounding the square portion of the stem. Serves alternatively to wind and to set the watch.

CLUTCH WHEEL—The wheel which engages the setting mechanism or the winding mechanism.

COCK—A piece which serves the purpose of a bridge, but rests on one end and is held by one screw, as the balance cock of all watches.

COLLET—The collar installed on the balance staff of a watch to which one end of the balance spring is attached.

COMPENSATING BALANCE—A balance whose rim is made of brass and steel to correct for errors caused by temperature variation. The diameter increases or decreases in different temperatures so as to compensate to quicken or slow down the vibration for changes in temperature.

COUNTERSHAFT—An intermediate shaft which receives motion from a main shaft and transmits it to a working part. Used by watchmakers to reduce cutting speed.

CRESCENT—A circular notch in the edge of the roller table for the reception of the guard pin or horn.

CROWN—A grooved circular piece fastened to the stem used for winding the watch.

DEMAGNETIZING—The operation of removing magnetic properties from a piece of iron or other magnetized object.

DETENT—The device which halts and releases, at the proper instant, the escapement of a clock or watch.

DIAL—The graduated face of a timepiece.

DIAL FOOT—One of the small metal pillars attached to the back of the dial for the purpose of holding the dial in place.

DIAL TRAIN—A train of two wheels and two pinions that control the progress of the minute hand and the hour hand.

DIAL WHEELS—The wheels constituting the motion work of a watch.

DIAMANTINE—A fine white powder mixed with oil to a stiff paste; used for polishing watch parts.

DISCHARGING PALLET—That pallet over which a tooth of the escape wheel slides in order to leave from between the pallets.

DOUBLE ROLLER—A roller unit consisting of two metal disks; the upper and larger disk supports the roller jewel and is called the impulse roller; the lower and smaller disk with the crescent notch serves as the safety roller.

DRAW—A force exerted by an escape wheel tooth upon the locking face of a pallet stone because of its slant, tending to bring the pallet lever against the banking pin and keep it there.

DROP—The distance a tooth of the escape wheel travels or DROPS when it passes from

the let-off corner of a pallet stone to the locking face of an intercepting pallet stone. Drop is also defined as the space through which an escape wheel moves without doing any work.

ENDSHAKE—Clearance or spacing between adjacent parts of a watch, or freedom of pivots to move endways. Some such freedom is necessary, since there is no force to spare in a watch and too tight a fit would stop the movement.

END STONE—A small disk of jewel upon which a watch pivot rests. (Often called a cap jewel.) It is found only in the escapement.

ELINVAR—A non-rusting, non-magnetizable alloy containing iron, nickel, chromium, tungsten, silicon, and carbon. Used for balance and balance springs.

ESCAPEMENT—That part of the watch movement which controls the rate of running. It regulates the motion of the train thus distributing the power of the main-spring. It communicates the motive power to the balance.

ESCAPE COCK—The bracket which supports the upper ends of the escape wheel and pallet staff arbors.

ESCAPE PINION—The pinion on the escape wheel arbor.

ESCAPE WHEEL—The last wheel of a train; it gives impulse to the balance, indirectly. Easily identified by its teeth, which resemble those of a circular saw. The escape wheel moves forward one tooth at a time.

FORK—The part located at the end of the pallet lever, containing the slot which the roller jewel enters. The fork delivers the impulse to the roller jewel.

FORK HORN—(See GUARD PIN.)

FORK SLOT—A notch cut into the fork for the reception of the roller jewel.

FORK TOOL—A thin metal rod used to hold the balance wheel while making certain adjustments.

FRICTION JEWEL—A jewel bushing in a watch movement which has been forced into place by pressure and stays there under friction alone. (Friction jewels do not have bezels. See jewel.)

FOURTH WHEEL—The wheel in a watch that drives the escape pinion and to which arbor the seconds hand is attached.

GAGE—A measuring instrument or device.

GOING BARREL—(See BARREL, GOING.)

GRAVER—A specially sharpened steel tool used with a lathe for a variety of cutting operations.

GRAVITY—The pull of earthly bodies towards the center of the earth.

GUARD PIN—The small brass pin working in and out of the crescent to preserve the safety action by assuring that the pallet will be in its proper position, ready to receive the jewel pin on its return trip. (Also called fork horn.)

GIMBAL—A contrivance resembling a universal joint permitting a suspended object to tip freely in all directions. Marine chronometers are supported in their cases by gimbals.

HAIRSPRING—(Also called balance spring.) A fine coiled wire, one end of which is attached by a collet to the balance staff and the other end to a stationary part of the watch called a stud. This spring assists the balance to vibrate and governs its time of vibration.

HAIRSPRING TRUING—Revolving the balance and inspecting the hairspring and, if necessary, bending the coils back in original position.

HANDS—The revolving pointers which indicate the hours, minutes, and seconds.

HEADSTOCK—The portion of the lathe which receives the power and which holds and rotates the work.

HEAVY POINT—The point on the rim of an out-of-poise balance wheel where the force of gravity appears to be centered when the watch is operating in the vertical position.

HORNS—The circular sides of the fork that lead to the fork slot. Part of the safety action which insures the escapement continuing in action should the watch receive a shock of sufficient force to throw the lever off its banking pin during unlocking and impulse action.

IMPULSE—The push transmitted to the pallet by the escape wheel.

IMPULSE FACE—The inclined plane on end of pallet stone on which the escape wheel teeth press to produce the lift of an escapement action.

IMPULSE PIN—The jewel pin—usually a ruby—on the table roller of the lever escapement, which, playing into the fork of the lever, transmits the impulse to the balance.

IN BEAT—A watch is said to be in beat when the same amount of power is required to start the balance in one direction as in the other. That is, there is no tension exerted by the balance spring to either side when the escapement is at dead center.

INDIA STONE—An artificially produced stone used for sharpening tools. Softer than the Arkansas stone.

ISOCHRONISM—The property of a balance spring that allows it to move through long and short arcs of motion in equal time; i.e., all its vibrations, of whatever length, are made in time periods exactly equal.

JEWEL—A precious stone which is pierced to receive the pivot. Jewels are used as bushings at the ends of pivots and in other places which sustain much wear. They

1. Provide smooth bearings for the pivots.
2. Obviate corrosion.
3. Reduce the wear from abrasion.

Sapphire is the best of the jewels in use; ruby is second.

JEWEL GAGE—A needle-shaped instrument provided with a scale for measuring jewel sizes.

JEWEL PIN—(Also called roller jewel.) A long, thin jewel, usually of ruby or sapphire, suspended perpendicularly in the roller. The jewel pin is the connecting link between the pallet and the balance wheel.

JEWEL PIN SHAKE—The clearance between the jewel pin and the horns of the fork when the pin is passing out of the fork slot at the time of the "drop."

LEAVES—The teeth of pinions.

LET-OFF CORNER—The extreme tip of the pallet stone where each successive tooth of the escape wheel loses contact with the pallet stone.

LEVER—In watchmaking, a metal piece to which the pallet arms are attached, and which serves to carry the impulse to the pallet from the escape wheel.

LEVER ESCAPEMENT—A watch escapement that delivers an impulse to the balance by means of two pallet stones and a lever. The extremity of the lever has a forked slot that acts directly on a roller jewel which is attached to the balance.

LIFT—The action which takes place when the impulse face of the escape wheel tooth engages the impulse face of the pallet stone or jewel.

LOCK—The amount of overlap between the pallet stone and an escape wheel tooth.

LOCKING FACE—That side of a pallet stone which locks or overlaps the tooth of an escape wheel (upon which the teeth of the escape wheel drop).

LOUPE—Also called eye lens; a piece of glass or other transparent material whose surfaces are ground to form an image by changing the direction of light rays, resulting in magnification of an object viewed through this lens.

MAINSPRING—A long ribbon of steel that supplies the power for driving a clock or watch. It is coiled into the circular metal box of the barrel with the outer end fastened to the barrel and the inner end to the barrel arbor.

MAINSPRING ASSEMBLY—The barrel, mainspring, and arbor combination.

MAIN TRAIN—The toothed wheels that connect the barrel with the escapement, causing the minute hand wheel to make one turn while the escapement makes a required number of beats.

MEAN-TIME SCREWS—Screws used to bring a watch to time, sometimes called timing screws.

MICROMETER CALIPER—A precision measuring device for determining diameters and thicknesses. The metric-calibrated type is usually used in watch repairing.

MIDDLE-TEMPERATURE ERROR—The temperature error between the extremes of heat and cold—an error characteristic of a compensating balance and steel balance spring, because the compensation balance does not exactly meet the temperature error. The rim expands too much with decrease of temperature and contracts too little with the increase. Hence, a timepiece can be correctly adjusted for two points only. The unavoidable error between is the middle temperature error.

MINUTE—The sixtieth part of a mean solar (sun) hour.

MINUTE HAND—Hand of a clock or watch which indicates the minutes. (First concentered with the hour hand in 1673.)

MINUTE WHEEL—The wheel which carries the minute hand and is driven by the cannon pinion.

MINUTE WHEEL PINION—The pinion on which the minute wheel is mounted and which drives the hour wheel.

MOTION—The amount of the circular movement of the balance wheel when oscillating. A motion of about 1 1/8 + turns is considered to be the most desirable.

MOTION WORK—The wheels in a watch which make the motion of the hour hand one-twelfth as rapid as that of the minute hand.

MOVEMENT—The watch or clock complete, without dial or case—the mechanism of the watch or clock.

NEEDLE GAGE—A measuring device consisting of a narrow scale calibrated to read the diameter of a jewel placed on its needle and pushed up into the gage.

OIL RESERVOIR—The spherical space around the pivot hole in a watch jewel where oil is stored to keep the watch lubricated.

OUT-OF-POISE—The watchmaker's term for describing a balance wheel or balance wheel assembly which is not balanced.

OVER BANKING—Pushing of the ruby pin past the lever, caused by excessive variation of the balance.

OVERCOIL—The outermost coil of a Brequet hairspring, which is carried up and over the rest of the spring.

PALLET—The metal body attached to or a part of the lever. The term includes the pallet arms and pallet stones. The pallet transmits the impulse from the escape wheel to the balance.

PALLET ARBOR—The axle on which the pallet oscillates.

PALLET ARMS—The metal body which contains the pallet stones.

PALLET STAFF—The axis of the pallet or arbor upon which it is mounted.

PALLET STONE—That part of an escapement which transmits the impulse from the escape wheel to the balance. Also defined as the jewel on the contact face of the pallet where it is struck by the teeth of the escape wheel.

PAWL—Another name for a dog, click, or ratchet.

PEGGING—The operation of using a sharpened stick of pegwood to clean or polish watch parts.

PILLAR—One of the three or four short brass posts which keep the plates at their proper distance apart.

PILLAR PLATE—The lower plate of a watch movement, nearest the dial.

PINION—The smaller of two toothed wheels which are geared into one another. The larger one is called the wheel.

PIVOT—The end of an axle or arbor which rests in a support.

PLATE—Disks of brass which form the foundation of the movement. The lower plate lies next to the dial. The upper pieces supporting one, two, or three wheels are usually referred to as bridges.

POISING—Adjusting the balance wheel so that its mass is distributed equally around the axis of rotation and the effect of the force of gravity is eliminated.

PUNCH, RIVETING—The flat-faced tool for flattening the riveting shoulder of a rivet-type staff.

PUNCH, SEATING—The tool used with the staking tool to spread the riveting shoulder when staking a balance wheel onto a rivet-type staff.

RATCHET—The pawl, or dog, which engages in the teeth of a ratchet wheel and prevents it from turning backward. It is held lightly against the periphery of the ratchet wheel by a small spring known as the ratchet spring.

RATCHET WHEEL—A wheel with triangular teeth fastened to the barrel arbor to prevent the mainspring from slipping back when it is being wound.

RATE (OF A WATCH)—The interval of time which a watch gains or loses in a given length of time, usually 24 hours.

REAMER—A small rotating finishing tool with cutting edges for enlarging or shaping a hole.

RECEIVING PALLET—That pallet stone over which a tooth of the escape wheel slides in order to enter between the pallet stones.

REGULATOR—The lever in a watch by which the pins regulating the swing of the hairspring are shifted.

REGULATOR PINS—The two small pins which embrace the hairspring and by being moved change the shape of the overcoil, and, consequently, the rate of the watch.

RIM WRENCH—A small hand tool notched at the end, used for forming balance wheel rims, etc.

ROLLER—The circular plate into which the jewel pin is set in a lever escapement.

ROLLER JEWEL—(See JEWEL PIN.)

ROLLER TABLE—A flat circular metal disk from which the roller jewel is suspended.

SECONDS HAND—The hand on the dial of a clock or watch which revolves once a minute. Sometimes small and set in a small circle of its own. Sometimes long and traversing the whole dial.

SECONDS PIVOT—The prolongation of the fourth wheel arbor to which the seconds hand of a watch is fixed.

SHAKE—The space separating the letting-off corner of the pallet from the heel of an escape wheel tooth when the opposite pallet is locked at the lowest locking corner.

SIDESHAKE—Freedom of pivots to move sideways. (See endshake.)

SLIDE—The distance the pallet stone slides on the escape wheel after the balance is moved from the position in which the jewel pin shake is tried.

STAKING TOOL—An anvil-type tool used with punches to fasten watch parts together, and to separate parts by exerting pressure at strategic points.

STEM—The winding arbor of a watch.

STUD—A small piece of metal pierced to receive the outer coil of the balance spring (hairspring).

STUMP—The small metal support used to hold a balance staff in position on the staking stand while the setting punch presses a balance arm down onto it.

TAILSTOCK—That portion of the lathe which was originated to support one end of the work, but now is used largely as a tool carrier (in horology).

T-REST—A support for steadying a graver while cutting on a jeweler's lathe.

THIRD WHEEL—The wheel in the train between the center wheel and the fourth wheel; it drives the fourth pinion.

TIMING SCREWS—Screws used to bring a watch to time, sometimes called mean-time screws.

TIMING WASHERS—Small washers punched out of extremely thin metal or foil, for use in poising balance wheels.

TRAIN—A series of two or more wheels and pinions, geared together and transmitting power from one part of a mechanism to another.

TRIPPING—The running past the pallet's locking face of an escape wheel tooth.

TRUING-IN-THE-FLAT—The operation of bending the rim of a balance wheel until (1) all parts of the rim lie in the same plane, and (2) the entire rim is perpendicular to the staff axis.

TRUING-IN-THE-ROUND—The operation of bending the rim of a balance wheel until it is concentric with the staff axis.

TURNING—A shaping or forming operation by use of the lathe.

UNDERCUTTING—Removing metal from the undersides of balance screws in the truing operation.

VERNIER CALIPER—A form of slide gage graduated in millimeters widely used by watch repairman. (This gage is also known as the Boley slide gage.)

WATCH ADJUSTING—The procedures employed in producing a uniform rate within well defined limits and under various conditions. Watch adjusting is divided into three branches: (1) position adjusting, (2) isochronal adjusting, and (3) temperature adjusting.

OFFICE MACHINES

BASKET SHIFT—When the shift key is depressed and released the segment and typebars of this type of machine move up and down.

BELL CRANK—A right angle lever for communicating motion as from one bell wire to another lying at right angles to it.

CARRIAGE SHIFT—When the shift key is depressed and released, the carriage of this type of machine moves up and down.

CYLINDER—(See platen.)

DROP (ROYAL)—The distance the carriage travels horizontally when, after a character has been printed, the machine backspaced one space, the space bar is depressed, and the same character printed again.

ECCENTRIC—A part whose axis is not centered with that of another part.

ESCAPEMENT—The mechanism which controls the movement of the carriage.

FULCRUM—The support or point of rest on which a lever turns.

KSM—Key set margin.

KST—Key set tabulator.

LOWER CASE—Print in small letters (not capitals).

MOTION—The alining on a horizontal line of the bottom of the upper case characters with the bottom of the lower case characters.

ON FEET—The adjustment made to cause the type face to print evenly with its top, bottom, and both sides.

OVERBANKING—The condition where the carriage moves one or more spaces past the position set by the margin stop.

PLATEN—The rubber covered cylinder or roller of a typewriter.

UPPER CASE—Print in capital letters.

UNDERBANKING—The condition where the carriage moves one or more spaces short of the position set by the margin stop.

GAGES AND METERS

ABSOLUTE PRESSURE—Pressure measured above a perfect vacuum. It is the pressure indicated by an ordinary pressure gage plus the atmospheric pressure.

AMMETER—An instrument for measuring electric current (in amperes).

AMMETER, SPLIT CORE—A portable current-measuring instrument which uses the magnetic field around a current-carrying conductor to produce a deflection of an indicating pointer.

AMPERE—The unit of quantity of electric current, being that produced by one volt acting through a resistance of one ohm. (Named after A. M. Ampere famous French physicist.)

ATMOSPHERIC PRESSURE—The pressure exerted by the atmosphere; not merely downwards, but in every direction.

BAFFLE—A plate, wall, or screen used to deflect, check, or otherwise regulate the flow of a gas, liquid, sound waves, etc.

BAROMETER—An instrument for determining atmospheric pressure and hence for judging probable changes of weather.

BATTERY (ELECTRIC)—A cell or combination of cells, which generates electrical current by chemical action.

BOURDON TUBE—A thin-walled, oval-shaped tube bent into the form of a C, which tends to straighten out when pressure is exerted in the tube. As the tube straightens, it is made to move a pointer around a dial.

BURETTE—A graduated glass tube, usually with a small opening and stopcock, for delivering measured quantities of liquid or for measuring the liquid or gas received or discharged.

CALIBRATION—The process of determining the capacity, or the graduations of, or to correct the readings of, as of dial instruments.

CANTILEVER ARM—A projecting beam or member supported only at one end.

CAPILLARY ATTRACTION—The action by which the surface of a liquid which is in contact with a solid is elevated or depressed.

CENTIGRADE—On the centigrade thermometer, the interval between the freezing point and the boiling point of water is divided into 100 parts or degrees, so that 0°C. corresponds to 32° F., and 100°C. to 212° F.

CENTRIFUGAL FORCE—That force which tends to drive a thing or parts of a thing, outward from a center of rotation.

CO_2 INDICATOR—An instrument designed to reveal the presence of carbon dioxide, a heavy colorless gas.

COMPARATOR—An instrument or machine for comparing anything to be measured with a standard instrument. Specifically, a self-contained portable pneumatic comparison-type pressure gage tester.

CONDENSATE—The product of condensation (the process of reducing from one form to another and denser form, as steam to water).

CONDUCTIVITY—The quality or power of conducting or transmitting heat, electricity, etc.

CONTROL SPRING—A small spring soldered onto the rotating mechanism of electrical meters (usually one at the top and one at the bottom of the shaft) to control and regulate the movement of the pointer.

CYCLE—When the voltage in an alternating current increases from zero to a maximum point, then decreases through zero to a maximum point in the opposite direction, then returns to zero again, a cycle is said to have been completed.

DAMPING DEVICE (ELECTRICAL)—A small metal disk mounted on the shaft of a moving element which turns between the poles of a permanent magnet. This motion sets up currents in the disk which oppose the motion of the moving magnet, resulting in a DRAG on the disk tending to stop it.

DEADWEIGHT TESTER—A hydraulic-balance type gage tester operating on the principle of subjecting the gage under test to a hydrostatic pressure created by applying weights to a piston of known area. The weighted piston applies pressure to a fluid, such as oil, in the cylinder which in turn is transmitted to the gage through a system of piping.

DIAPHRAGM POINTER GAGE—A pressure or vacuum gage containing a thin disk or membrane, whose indicating pointer moves in accord with the vibrations of the disk or membrane.

DIFFERENTIAL EXPANSION—The property of some metals or other solids to expand at different rates when heated. (See expansion coefficient.)

DIFFERENTIAL PRESSURE GAGE—A Bourdon-type gage equipped with two Bourdon tubes so arranged as to measure the difference in pressure between two pressure lines. Bellows gages also measure differential pressure.

ELECTRICAL RESISTANCE—The opposition offered by a substance or body to the passage through it of an electric current or magnet flux.

ELECTRODE—Either terminal of an electric source. An electrode may be a wire, a plate or other electricity-conducting object.

ELECTROMOTIVE FORCE—That which moves, or tends to move, electricity.

EXPANSION COEFFICIENT—The ratio of the increase of length, area, or volume of a body for a given rise in temperature to the original length, area, or volume. Also called coefficient of expansion.

FAHRENHEIT—On the Fahrenheit thermometer, under standard atmospheric pressure, the boiling point of water is at 212° F. and the

freezing point at 32° F. above the zero of its scale.

FILAMENT—A threadlike conductor, as of carbon or metal, that is made incandescent by the passage of an electric current.

FLUE GAS (STACK GAS)—Gas taken from the flue or chimney used to convey flames, smoke, and hot gases around or through water in a boiler.

FREQUENCY—The number of cycles (as in an alternating electrical current) completed per second is called the frequency.

GALVANOMETER—An instrument for measuring a small electric current, or for detecting its presence or direction by means of the movements of a magnetic needle, or of a coil in a magnetic field.

GOVERNOR—An automatic attachment to an engine, compressor, etc., for controlling its speed.

HELIX—Anything having a spiral shape. (Mathematically, a helix is the shape of the curve formed on any cylinder by a straight line in a plane that is wrapped around the cylinder, such as an ordinary screw thread.)

HEXANE—A colorless, explosive gas of the petroleum series.

HYDRAULIC—Conveying, acting, or operating by water (or some other liquid).

HUMIDIFIER—A baffled water container having a gastight dividing wall; gas and air pass over the water surfaces and become moistened.

HYDRAULIC RAM—The plunger of a hydrostatic press.

HYDROSTATIC—The branch of physics which relates to the pressure and equilibrium of liquids.

INDUCTION (ELECTRICAL)—The process by which (1) an electrical conductor becomes electrified when near a charged body, or (2) a magnetizable body becomes magnetized when in a magnetic field, or (3) an electricity moving force is produced in a circuit by varying the magnetic field linked with the circuit.

INERT GAS—A gas which has no active chemical properties.

KEEPER—In the electrical trade, a piece of steel or soft iron used to connect the poles of a magnet to preserve the intensity of the magnetization.

KILOWATT—A unit of electrical power, equal to 1,000 watts. (A watt is a unit of power equal to the rate of work represented by a current of one ampere under a pressure of 1 volt.)

LEVELOMETER—A gage which operates on the hydrostatic principle, employing a dial-type indicator, to measure the contents of tanks.

LIQUIDOMETER—A float-actuated, remote-reading gage operating on the balanced hydraulic principle to measure the contents of tanks.

MAGNETO—An electrical device with permanent magnets, used to generate the current for the electric ignition of internal-combustion engines, etc.

MENISCUS—The curved upper surface of a liquid column; concave when the containing walls are wetted by the liquid (as with water), and convex when not (as with mercury).

MANOMETER—A gage for measuring the pressure of gases and vapors.

OHM—The unit of electrical resistance, being the resistance of an electrical circuit in which an electrical pressure of 1 volt produces a current of 1 ampere.

PNEUMERCATOR—A hydrostatic-type tank level indicator, operating on the principle of balancing a head of liquid in a tank against a column of mercury or other indicating medium enclosed in a gage.

POLARITY (ELECTRICAL)—The particular state (positive or negative) of a body with reference to the two poles.

POWER FACTOR—The ratio of the apparent power in an electrical circuit to the true power, expressed in percent. In direct current circuits the power factor is always 1; in alternating current circuits it is usually less than 1. (For a detailed explanation of power factor, see page 219 of Electrician's Mate, 2d Class, NavPers 10103.)

PRESSURE—Pressure is force per unit of area.

PRESSURE DIFFERENTIAL—A difference in pressure.

P.S.I.—Abbreviation for pounds per square inch.

PYROMETER—An instrument for measuring temperatures, particularly those beyond the range of mercurial thermometers, as by means of the change of electric resistance, the production of a thermoelectric current, the expansion of gases, etc.

RESISTOR—A device possessing the property of electrical resistance, used in an electric circuit for protection operation or control.

SALINITY INDICATOR—An indicating gage which measures the approximate salt content of fresh water. It operates on the principle

that the electrical conductivity of water varies with its chemical impurity content.

STATIC CHARGE—A stationary charge of electricity, such as that produced by rubbing together unlike bodies, as amber and cloth, a glass rod and silk, etc.

STATIC FRICTION—The resistance to relative motion of two bodies in contact.

TACHOMETER—A speed counter.

TANK LEVEL INDICATOR—A hydrostatic-type tank gage, usually operating on the principle of balancing a head of liquid in a tank against a column of mercury, or on the balanced hydraulic principle employing a float-actuated remote reading dial gage. (See Levelometer, Liquidometer, and Pneumercator.)

TERMINAL (ELECTRICAL)—A device attached to the end of a wire or cable or apparatus for convenience in making electrical connections.

THERMAL ALARM—A temperature alarm signal device, used on Navy vessels go give warning of excessive superheater temperatures. A light, a horn, or both types of warning may be employed.

THERMOCOUPLE PYROMETER—A temperature measuring instrument using the change of electric resistance of a conductor when heated to indicate the temperature being measured.

THERMOELECTRIC—Of or pertaining to electricity produced by the direct action of heat, as by the unequal heating of a circuit composed of two dissimilar metals.

TORQUE—That which produces or tends to produce rotation.

VACUUM—A space exhausted to a very high degree by an air pump or some other means. Vacuum (below atmospheric) pressures are usually indicated in inches of mercury.

VAPOR INDICATOR—An electrochemical device used to detect the presence of explosive or flammable mixtures.

VISCOSITY—The ability of a liquid to cling, or resist flowing.

VOLT—The unit of electromotive force, defined as the force which steadily applied to a circuit whose resistance is one ohm will produce a current of one ampere.

VOLTAGE—The electric potential difference, expressed in volts.

VOLTMETER—An instrument for measuring in volts the difference of potential between different points of an electrical circuit.

WATT—The unit of electric power, equal to the rate of work represented by a current of one ampere under a pressure of one volt.

WATTMETER—An instrument for measuring electric power in watts.

WATT-HOUR METER—A device used to record electric energy, usually in kilowatt hours.

WHEATSTONE BRIDGE—A device for the measurement of electrical resistance, invented by Sir Charles Wheatstone, English physicist.

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